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Hardware vs. Manpower Comparability Methodology

Step 6: Tradeoff Analysis
Volume 7

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The Army Hardware vs. Manpower (HARDMAN) Comparability Methodology (HCM) is a six-step process for determining a weapon system's manpower, personnel, and training (MPT) requirements. It provides a structured approach for early MPT estimation based on comparability analysis, an analytic system that uses knowledge about similar existing systems and technological growth trends to project the MPT requirements of proposed new systems. The HCM's six interrelated steps are Systems Analysis, Manpower Requirements Analysis, Personnel Pipeline Analysis, Training Resource Requirements Analysis, Impact Analysis, and Tradeoff Analysis. The HCM has been successfully applied to a range of weapons systems, including air, armor, artillery, infantry, air defense, command and control, and intelligence systems.

The Product Improvement Program for HCM made major revisions to the existing HCM Guide. The scope has been expanded to include several new areas; existing (Continued)

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19. ABSTRACT (Continued)

procedures have been revised, refined, and clarified; and the entire Guide has been rewritten to achieve greater clarity, consistency, and completeness.

This volume addresses identification and selection of tradeoff options. System design or concept alternatives are identified that will reduce the effect of "high drivers" (identified in Step 5, Impact Analysis) on MPT resources. The constraints on tradeoffs are discussed.

Research Product 90-19G

Hardware vs. Manpower Comparability Methodology

Step 6: Tradeoff Analysis
Volume 7

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FOREWORD

The goal of the Army HARDMAN methodology is to provide timely information on the manpower, personnel, and training (MPT) resource requirements of emerging weapon systems. This information supports decisions on the research, development, and acquisition issues affecting emerging systems, as well as planning required for effective supportability of these systems in MPT and logistics areas. HARDMAN is a key element of the Army MANPRINT program.

This guide consists of seven volumes, a manager's guide and one volume for each of the six steps of the HARDMAN methodology. The manager's guide is intended for the use of the manager in the planning, scoping, and costing of the HARDMAN analysis. The other six volumes are for the analysts who will perform the analytic procedures in each step of the methodology.

This volume is the manager's guide. It deals with the planning and conducting of the HARDMAN analysis and the estimation of the resource requirements for the analysis. Development of the quality assurance plan and the consolidated database are explained. The relationship of HARDMAN results to various Army MPT documents is also discussed.

This guide is a major revision and expansion of the existing five-volume HARDMAN guide. The scope has been altered to include procedures for assessing combat damage workload and depot-level manpower requirements, and estimating training resource requirements associated with new training concepts and other procedures not included previously. Existing procedures have been clarified, simplified, or expanded to make them more useful to the analyst and to make HARDMAN a more effective tool for the Army.

The development of the guide was part of the System Research Laboratory's Third Generation MANPRINT Estimation Research Task. Most of the expansion and enhancement of the HARDMAN method has been based on recommendations of the Soldier Support Center, National Capital Region (SSC-NCR), which has overseen application of the method to numerous Army weapon systems. Staff from the SSC-NCR attended all the in-progress reviews for this effort and have been briefed on the final product. In addition, personnel from the TRADOC Analysis Command, White Sands Missile Range, TRADOC Headquarters, the U.S. Army Human Engineering Laboratory, and other Army agencies have been briefed on the revised HARDMAN guide to make them aware of its enhanced capability to provide MPT information for emerging systems.

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HARDWARE VS. MANPOWER COMPARABILITY METHODOLOGY (STEP 6: TRADEOFF ANALYSIS) (VOLUME 7 OF 7)

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HARDWARE VS. MANPOWER COMPARABILITY METHODOLOGY
(STEP 6: TRADEOFF ANALYSIS)
(VOLUME 7 OF 7)

INTRODUCTION

"Tradeoff Analysis" is the sixth step in the Army HARDMAN Comparability Methodology (HCM). The HCM is a Manpower and Personnel Integration (MANPRINT) tool that addresses manpower, personnel, and training (MPT) issues associated with new or improved weapon systems.

This document is one of seven documents that contain the steps necessary to conduct an HCM analysis:

"Overview and Manager's Guide"

"Step 1: Systems Analysis"

"Step 2: Manpower Requirements Analysis"

"Step 3: Personnel Pipeline Analysis"

"Step 4: Training Resource Requirements Analysis"

"Step 5: Impact Analysis"

"Step 6: **Tradeoff Analysis**"

How this Document is Organized

An HCM step consists of an overview and substeps. A substep contains an overview and action steps. Each action step includes a discussion of what the analyst will accomplish in the action step; procedures that describe, step-by-step, how to accomplish the action step; and examples that feature actual Army systems. The table on the following page summarizes the procedures the analysis team must undertake to accomplish this HCM step.

Worksheets are used extensively throughout the guide. These worksheets help the analysis team organize and format information and serve as an audit trail of the analysis. Blank copies of these worksheets are located at the end of each substep.

Each HCM step has its own unique appendices. These appendices include articles that provide additional information about the step; a list of acronyms; a glossary; a crosswalk between the HCM and the Man Integrated Systems Technology (MIST); and a crosswalk between the HCM and MPT-related Army documents, for example, Basis of Issue Plans (BOIPs) and the Qualitative and Quantitative Personnel Requirements Information (QQPRI). (Each step's appendix section does not include a list of references. The "Overview and Manager's Guide" includes a complete list of references for all seven volumes.)

Step 6's Substeps and Actions Steps

IN THIS SUBSTEP	THE ANALYST WILL	BY COMPLETING THIS ACTION STEP
6.1	Select Tradeoff Options	Identify Tradeoff Options Prioritize Tradeoff Options and Recommend Tradeoffs Select Tradeoffs and Identify Tradeoff Methods
6.2	Perform a ROM Tradeoff Analysis	Evaluate MPT Parameter Relationships Determine ROM MPT Estimates
6.3	Perform a Detailed Tradeoff Analysis	Conduct a Detailed Tradeoff Analysis

STEP 6
TRADEOFF ANALYSIS

Overview

The HCM analysis team's objective in this step is to identify and select tradeoff options. Figure 6-1 shows the relationship of Tradeoff Analysis to other HCM steps. Figure 6-2 is an overview of this step.

Each analyst identifies tradeoff options for his or her step by examining system design/concept alternatives that will reduce the effect of "high drivers" on MPT resources. (High drivers are identified in Step 5, Impact Analysis.) The analysis team then prioritizes the tradeoff options and presents them to the Technical Advisory Group (TAG) for selection. The TAG and HCM team then determine the tradeoff methods to be used, i.e., a rough order of magnitude (ROM) analysis or detailed tradeoff analysis.

In a ROM analysis, the analysts determine the direct effect of tradeoff options on the appropriate workload or MPT parameter. From these effects the analysts attempt to gain further insight to the Now System's resource problems.

In a detailed tradeoff analysis, the analysts return to previous HCM steps and introduce system-design or system-concept changes. The analysts then study the impact these changes have on the system's MPT requirements.

The New System's position in the acquisition cycle will influence the HCM analysts' tradeoff choices. If, for example, a system is early in its acquisition cycle, the analysts will have more freedom in proposing tradeoffs because the system's hardware will not be "locked in." If a system is near its production phase, however, the analysts will have a narrower range of possible tradeoffs.

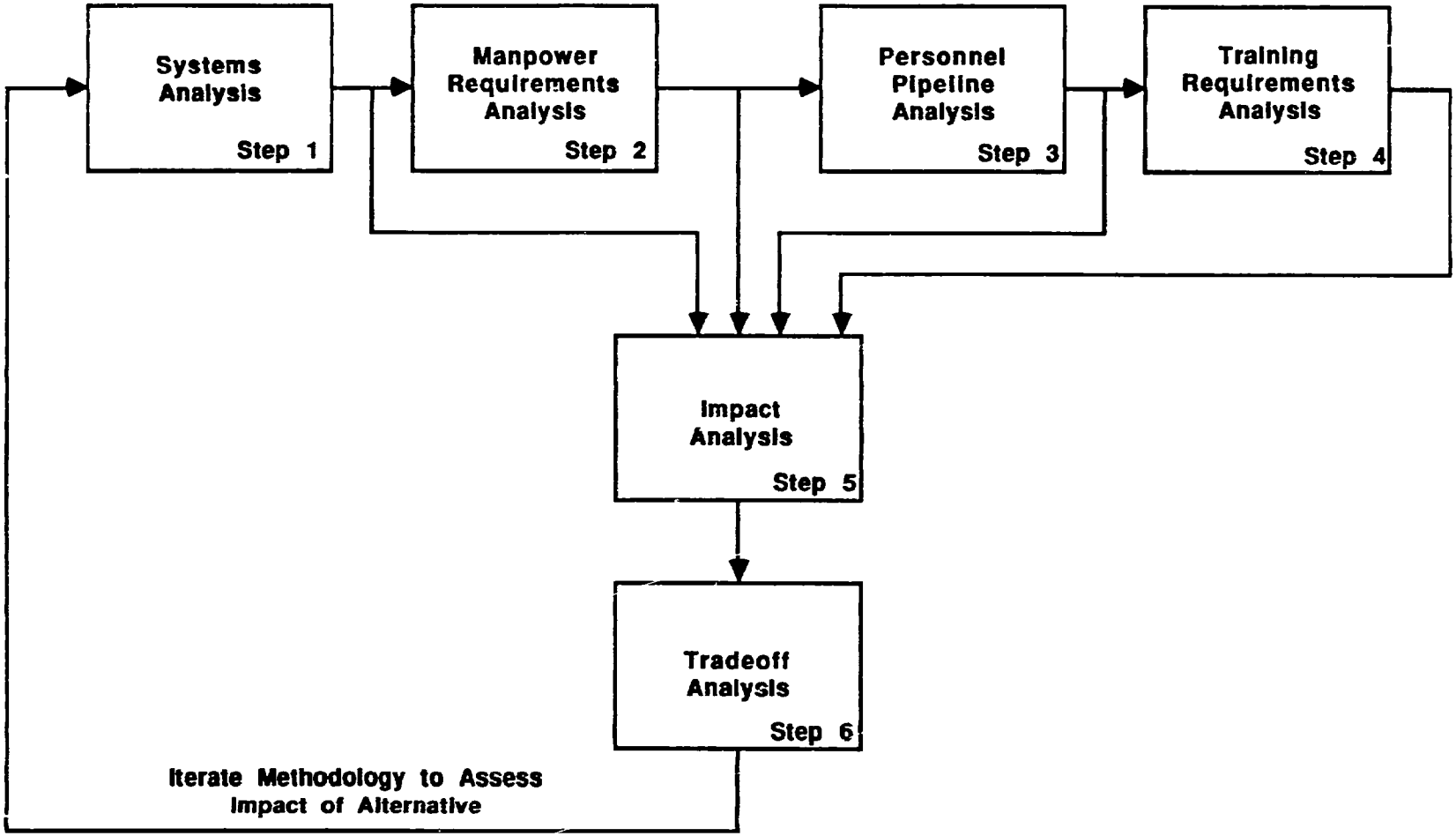

Figure 6-1. Relationship of Tradeoff Analysis to other HCM steps.

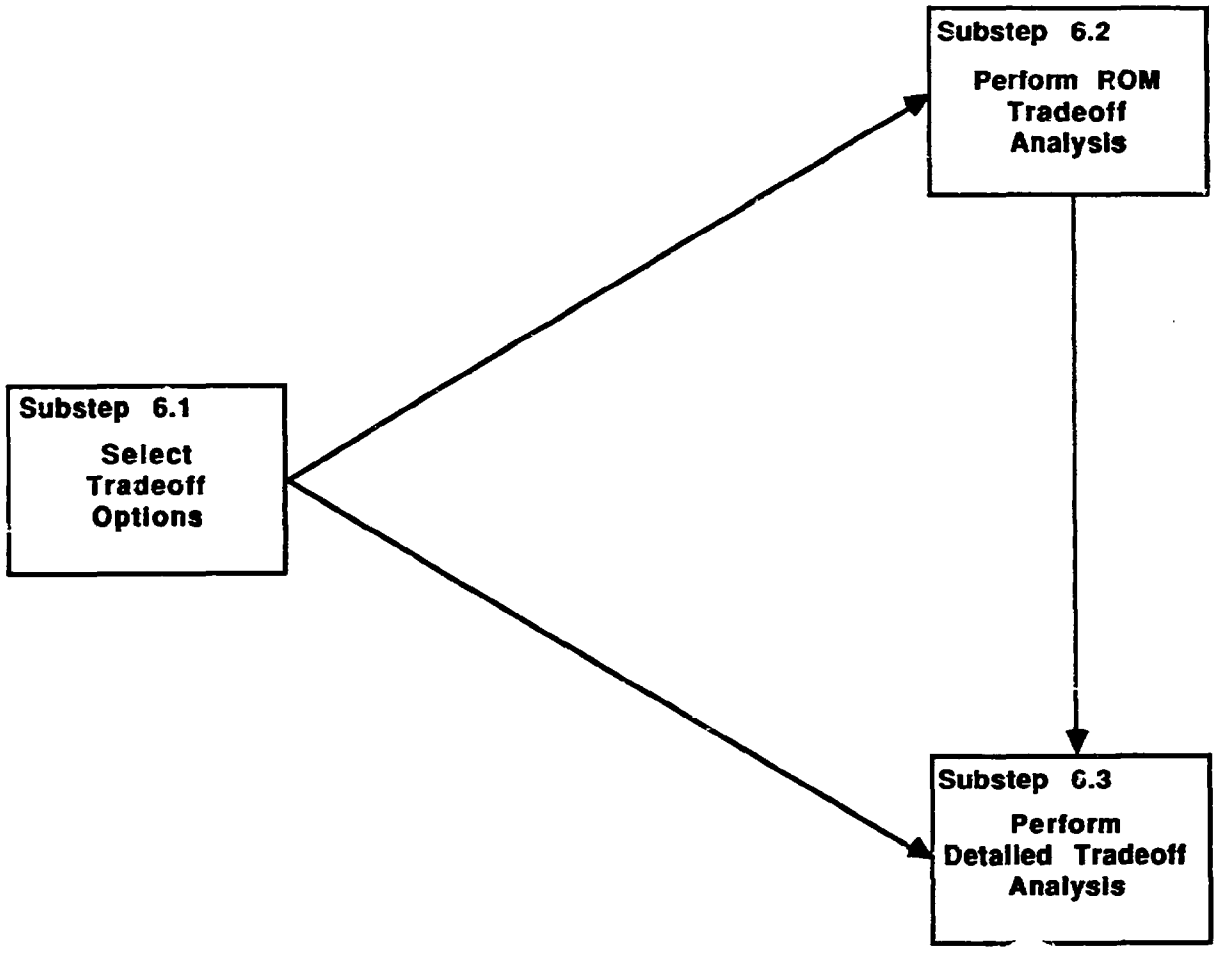

Figure 6-2. Overview of Step 6, Tradeoff Analysis.

Substep 6.1: Select Tradeoff Options

Overview

In this substep each HCM analyst develops a set of prioritized tradeoff options for his or her step. The analysis team then presents these tradeoffs to the TAG. The TAG selects the options it wants the HCM analysis team to pursue, either as rough order of magnitude (ROM) analyses or as detailed tradeoff analyses (iterations of one or more HCM steps). Figure 6.1-1 is an overview of this substep.

The TAG can make one of three choices for each tradeoff option presented. The TAG can decide to (1) proceed with the tradeoff as recommended, in which case the TAG must decide between a ROM or a detailed tradeoff; (2) refer the issue to a higher authority; or (3) drop the tradeoff. Figure 6.1-2 illustrates the tradeoff analysis decision-making process.

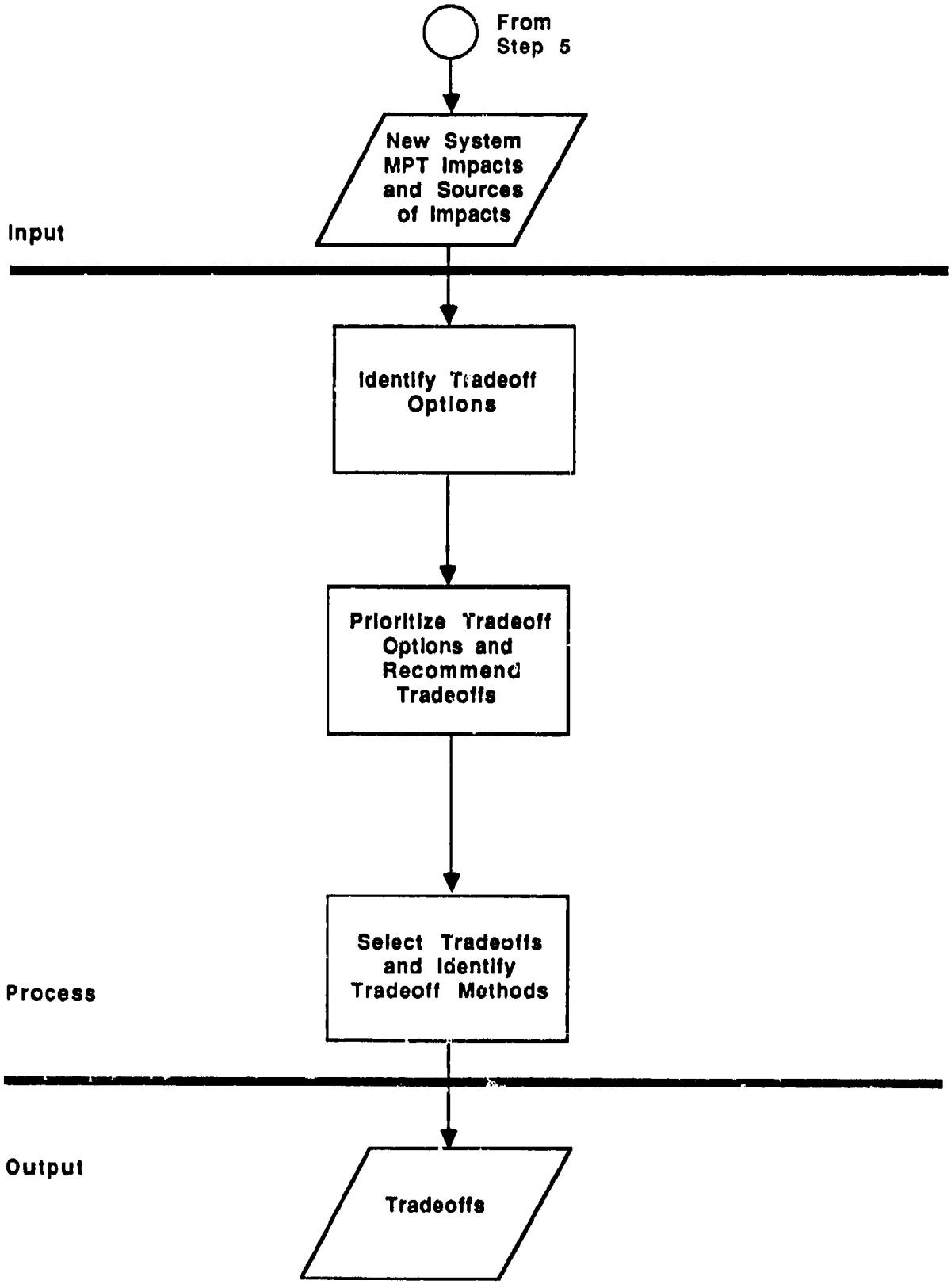

Figure 6.1-1. Overview of Substep 6.1, Select Tradeoff Options.

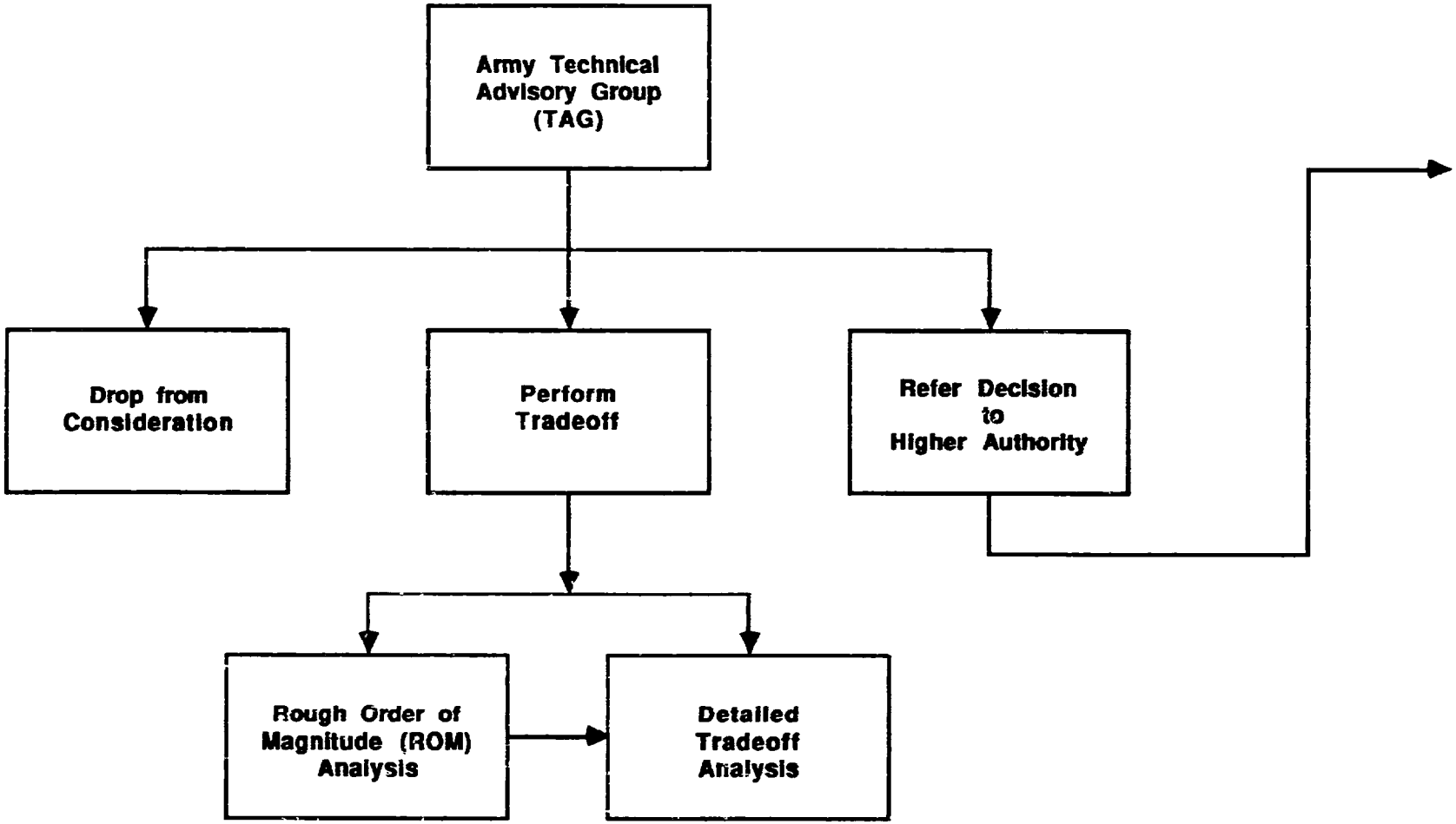

Figure 6.1-2. Tradeoff analysis decision-making process.

Action Step 1: Identify Tradeoff Options

Discussion

In this action step the analyst uses the System Characteristics column of Table 6.1-1 and the MPT high drivers identified in Step 5 to identify potential tradeoff options. The analyst identifies tradeoff options that will reduce MPT requirements associated with a Proposed System alternative. He or she examines system characteristics for their potential to reduce high maintenance, workload, and/or MPT requirements.

Procedures

1. **Identify Tradeoff Options to Reduce Maintenance Requirements.**
   - Obtain the results of Substep 5.1.
   - Review the sources of high maintenance requirements.
   - Indicate the tradeoff type (i.e., R&M) on Worksheet 6.1-1.
   - Record the tradeoff options (i.e., alternative equipment, R&M characteristics, and operational concept, etc.) on Worksheet 6.1-1. Number each tradeoff option.
2. **Identify Tradeoff Options to Reduce High Workload Requirements.**
   - Obtain the workload-related impact analysis results from Substep 5.2.
   - Review the sources of high workload values.
   - Indicate the tradeoff type (i.e., W) on Worksheet 6.1-1.
   - Record the tradeoff options (i.e., alternative equipment, usage rates, maintenance concepts, O&O concepts, etc.) on Worksheet 6.1-1. Number each tradeoff option.
3. **Identify Tradeoff Options to Reduce High Manpower Requirements.**
   - Obtain the manpower-related impact analysis results from Substep 5.2.
   - Review the sources of high manpower requirements.
   - Indicate the tradeoff type (i.e., M) on Worksheet 6.1-1.
   - Record the tradeoff options (i.e., alternative system densities; force structure; Annual Available Productive Man-Hours (AAPMH); maintenance concept; workload; etc.) on Worksheet 6.1-1. Number each tradeoff option.

Table 6.1-1. HCM Assumptions/Procedures and System Characteristics that Impact MPT Results.

HCM MPT Output Parameter	HCM Assumptions/Procedures	System Characteristics
R&M Characteristics	Selection/Manipulation of R&M Data Sources Selection of Equipment Allocation of R&M Data Across Maintenance Levels	R&M Values BCS Equipment Selection Maintenance Concept Equipment Usage Rates
Workload	Operational Use Parameters MOS/Skill Level Selection	Support Concepts Maintenance Concept Operational Scenario System Configuration
Manpower	Workload Aggregation Procedures (Roll-Up) Manpower Rounding Procedures (Fractional Number Manpower vs. Whole Number Manpower)	Available Productive Man-Hours Manpower Policy Force Structure
Personnel	Comparable MOS Selection Manpower Skill Level Distribution	Promotion Rate Migration-In Rate Migration-Out Rate Attrition Rate TTHS Rate
Training	Training Media Selection Comparable Course Selection	Student/Instructor Ratio Training Concept Training Location

4. **Identify Tradeoff Options to Reduce High Personnel Requirements.**

   - Obtain the personnel impact analysis results from Substep 5.3.
   - Review the sources of high personnel requirements.
   - Indicate the tradeoff type (i.e., P) on Worksheet 6.1-1.
   - Record the tradeoff options (i.e., re-enlistment incentives, segmented training, etc.) on Worksheet 6.1-1. Number each tradeoff option.

5. **Identify Tradeoff Options to Reduce High Training Resource Requirements.**

   - Obtain the training impact analysis results from Substep 5.4.
   - Review the sources of high training requirements.
   - Indicate the tradeoff type (i.e., T) on Worksheet 6.1-1.
   - Record the tradeoff options (i.e., alternative training concepts, course length, training location, etc.) on Worksheet 6.1-1. Number each tradeoff option.

Procedure 1 Example

The analyst obtains the results from Substep 5.1. (This example is a continuation of the example in Substep 5.1.)

EIC	Equipment Nomenclature	BCS AVIM MR	New System AVIM MR	
303	TADS/PNVS Subsystem	0.3946	0.4025	(1)
306	Area Weapon Subsystem	0.1521	0.1521	
302	Fire Control Subsystem	0.1189	0.1189	(2)
301	Armament Control Subsystem	0.1040	0.1040	
304	Aerial Rocket Subsystem	0.1010	0.0606	
305	HELLFIRE Subsystem	0.0098	0.0098	
		0.8804	0.8479	

(1) The analyst notes that the New System TADS/PNVS is an extremely high driver of maintenance requirements. This MR was extrapolated from a BCS MR that is also very high. Alternative target acquisition and pilot night-vision systems will be available for use in the New System.

(2) The New System's Fire Control System is an integrated system that handles all weapons systems on the aircraft. Segregated Fire Control systems in Navy and Marine aircraft require less maintenance because of less complex designs.

The analyst determines the following tradeoff options:

Type	Number	Tradeoff Option Description
R&M	1	Use alternative TADS/PNVS BCS equipment available from the Navy or other sources.
R&M	2	Replace the fully integrated Fire Control System with a segregated system.

Procedure 2 Example

The analyst obtains the workload analysis results from Substep 5.2. (This example is a continuation of the example in Substep 5.2.)

Maintenance Level	MOS	MMH	
AVUM	67R/Y	1881.8	
AVUM	68J	1044.7	
AVUM	35K	739.6	(1)
AVUM	68M	433.8	
AVUM	66R	277.5	
AVUM	68F	259.2	
AVUM	66J	221.8	
AVUM	68G	174.7	
AVUM	68B	90.1	
AVUM	68D	71.9	
		5195.1	

Maintenance Level	MOS	MMH	
AVIM	68F	841.2	(2)
AVIM	68J	455.3	
AVIM	68M	342.8	
AVIM	68G	311.3	(3)
AVIM	66R/Y	246.3	
AVIM	68H	209.5	
AVIM	39B	205.9	
AVIM	68B	199.1	
AVIM	35L	155.6	
AVIM	35M	128.7	
AVIM	66J	119.7	
AVIM	68D	81.8	
AVIM	29S	10.1	
AVIM	67R	6.0	
		3313.3	

(1) Proposed System equipment that MOS 35K will maintain is existing Government Furnished Equipment (GFE) that is not being redesigned. However, the GFE uses old technologies that require excessive maintenance. The cost of maintaining the GFE may exceed the cost of its redesign.

(continued)

Procedure 2 Example (continued)

(2) The cockpit in the Proposed System integrates a large number of electronic subsystems. However, the Proposed System design does not include integrated diagnostic test equipment to assist the maintainers. MOS 68F workload can be reduced significantly by including diagnostic equipment as a part of the integrated cockpit.

(3) MOS 68G workload is high due to an anticipated increase in stress fractures of the helicopter skin. The stress fractures are of the type that do not significantly reduce safety but do require maintenance attention. The stress fractures could be reduced with a strengthened frame and fuselage.

The analyst determines the following tradeoff options:

Type	Number	Tradeoff Option Description
W	3	Redesign GFE (avionics and communication equipment) to reduce MOS 35K's maintenance responsibilities.
W	4	Replace the GFE equipment with available contractor equipment. Contractor equipment that is equivalent to or exceeds New System requirements can be substituted. Data for the equipment must exist.
W	5	Include integrated diagnostic equipment as part of the integrated cockpit design.
W	6	Strengthen helicopter tail frame and fuselage.

Procedure 3 Example

The analyst obtains the manpower requirements from Substep 5.2:

Organizational Unit: Attack Battalion III (ATKH BN III) (AVUM)
Aircraft Density Within Unit: 18 Proposed

Maintenance Level	MOS	Proposed Manpower
AVUM	67R/Y	27
AVUM	68J	15
AVUM	35K	11
AVUM	68M	6
AVUM	68F	4
AVUM	66R/Y	4
AVUM	66J	3
AVUM	68G	3
AVUM	68D	1
AVUM	68B	1
		75

Organizational Unit: III Corps (AVIM)
Aircraft Supported by Unit: 63 Predecessor, 54 Proposed

Maintenance Level	MOS	Proposed Manpower
AVIM	68F	32
AVIM	68J	17
AVIM	68M	13
AVIM	68G	12
AVIM	66R/Y	9
AVIM	39B	8
AVIM	68H	8
AVIM	68B	8
AVIM	35L	6
AVIM	35M	5
AVIM	66J	5
AVIM	35R	5
AVIM	68D	3
AVIM	67R/Y	1
AVIM	29S	1
		133

(continued)

Procedure 3 Example (continued)

Manpower results for the Proposed System were originally computed using Annual Available Productive Man-Hour (AAPMH) values of 1,241 at AVUM and 1,423 at AVIM. Recently, new AVUM/AVIM AAPMH values of 2,225 and 2,631 were introduced. This change in AAPMH alters a key parameter used in computing manpower and will have a dramatic effect on the manpower requirements. The full impact of this change should be evaluated in a tradeoff analysis.

The analyst determines the following tradeoff option:

Type	Number	Tradeoff Option Description
M	7	Use AVUM/AVIM AAPMH of 2,225/2,631 to compute Proposed System manpower.

Procedure 4 Example

The analyst obtains the personnel requirements from Substep 5.3:

MOS/Paygrade		Personnel Requirements
67R	E-7	8
	E-6	166
	E-5	424
	E-4	698
	E-1 to E-3	954
	Total	2,250
35K	E-7	8
	E-6	104
	E-5	263
	E-4	395
	E-1 to E-3	485
	Total	1,255
68D	E-7	0
	E-6	16
	E-5	32
	E-4	49
	E-1 to E-3	66
	Total	163

Because of MOS 35K's extensive avionics training, the first-term re-enlistment rate for this MOS is far below average.

(continued)

Procedure 4 Example (continued)

Because of MOS 68F's extensive electrical training, the first-term re-enlistment rate for this MOS is far below average.

The analyst identifies the following tradeoff options:

Type	Number	Tradeoff Option Description
P	8	Offer a first-term re-enlistment bonus to MOS 68F.
P	9	Segment MOS 68F's training so that advanced electronics training is offered after first-term re-enlistment or as a re-enlistment incentive.
P	10	Offer a first-term re-enlistment bonus to MOS 35K.
P	11	Segment MOS 35K's training so that advanced avionics training is offered after first-term re-enlistment or as a re-enlistment incentive.

Procedure 5 Example

The analyst obtains the following training man-day results from Substep 5.4:

Course Number	Annual Training Man-Days
646-68J10	127,669
600-67R10	85,612
602-68F10	85,108
102-35K10	46,091
646-68M10	25,148
603-68G10	19,889
102-35R10	10,735
601-68B10	8,873
102-35L10	8,327
198-39B10	7,417
102-35M10	7,224
602-68D10	5,993
646-68J30	4,605
68H/C3ABR42334-00	3,900
602-68F30	2,783
AH-68H	1,650
35R/4C-F17/102-ASIW6	1,680
600-66R20	1,653
160-29S10	1,383
35K/4C-F18/102-ASIW6	968
600-67R30	857
39B/198-ASIX1	678
600-66J30	644
603-68G30	549
601-68B30	274
603-68H30	235
160-29S30	87
602-68D30	78
	460,310

In accordance with the current training concept, electrical system training for MOS 68F (courses 602-68F10 and 602-68F30) uses actual aircraft. Due to space limitations within the aircraft, the student-instructor ratio for these modules of instruction is only 3:1 (as opposed to the normal 6:1). In addition to increasing the instructor requirements, this constraint lengthens the course. About 10 percent of the course is taught using the actual aircraft.

(continued)

Procedure 5 Example (continued)

The high training man-day requirement for course 102-35K10 is due to the requirement to train MOS 35K personnel on new avionics equipment installed on the system. Formal training time may be reduced by teaching skills at the apprentice level for new equipment and by transferring proficiency training to the field units as on-the-job training (OJT).

The analyst identifies the following tradeoff options:

Type	Number	Tradeoff Option Description
T	12	Develop a training device for MOS 68F's electrical system training to reduce training on the actual aircraft.
T	13	Assign MOS 35K's proficiency training, included in course 102-35K10, to OJT in the unit.

Action Step 2: Prioritize Tradeoff Options and Recommend Tradeoffs

Discussion

In this action step the HCM analysis team uses three criteria to prioritize tradeoff options for the Technical Advisory Group (TAG). The team must answer the following questions to determine priorities:

(1) Does the tradeoff resolve a MANPRINT issue?

(2) Does the tradeoff reduce an MPT demand that exceeds the New System's goals?

(3) Is the tradeoff feasible?

The HCM analysis team must weigh the following issues when it considers the tradeoffs' feasibility:

(1) Acquisition Phase - Early in a system's acquisition, the TAG can consider some tradeoffs that would not be feasible later on. For example, if the HCM analysis determines that vehicle tracks are creating a major MPT problem, the team could study wheels as a design alternative. Later in the acquisition process, this tradeoff would not be as feasible.

(2) Scope of Authority - The TAG is more likely to pursue tradeoff analyses of issues over which it has control. For example, the TAG may have substantial authority to alter certain elements of the New System's design and concepts early in the New System's acquisition. However, a tradeoff that would require a change to Army manpower policies, such as extending initial enlistment to six years, is beyond the TAG's authority.

(3) Analysis Cost - The HCM analysis team must be prepared to discuss the resources (cost) required to perform the tradeoff analysis.

(4) Secondary Effects of the Tradeoff Solution - A solution to one problem will be acceptable to the TAG only if it will not create a secondary problem that is equal to or exceeds the original problem. Reducing one manpower cost by increasing another may not be a feasible tradeoff. The HCM analysis team must be prepared to discuss this issue with the TAG.

The HCM analysts assign the highest priority to those tradeoffs that will resolve MANPRINT questions and New System constraints. Priority is assigned to these tradeoffs because failure to resolve the issue that has prompted the tradeoff could stop the New System's acquisition.

Procedures

1. **Prioritize Tradeoff Options.**
   - Review Worksheet 6.1-1. Prioritize the tradeoff options for each of the five categories of tradeoffs (maintenance requirements, workload, manpower, personnel, and training) according to the anticipated effect the tradeoff option will have on MPT resources.
   - On Worksheet 6.1-2, list the tradeoff options in order of priority, assigning tradeoffs with the highest priority #1, #2, #3. . . in descending order.
2. **Assess Tradeoffs' Feasibility.**
   - Answer the following questions for each tradeoff option. Place the proper response in the appropriate column on Worksheet 6.1-2.
   - Is the implementation of the tradeoff option unlikely because changing system design or other acquisition decisions would not be cost effective. Write yes or no in the Acquisition Phase column.
   - Is implementation of the tradeoff option beyond the TAG's authority. Write yes or no in the Scope of Authority column.
   - Estimate the cost of each option (i.e., high, medium, or low). Write "H," "M," or "L" in the Cost column.
   - Will the solution provided by the tradeoff option create secondary problems? If the answer to this question is yes, indicate these secondary problems in the Notes column.
3. **Recommend Tradeoffs.**
   - Use on the following aproaches to recommend each tradeoff:
     - Recommend to the TAG ("RT") tradeoff options that could provide results that would reduce New System MPT impacts that currently exceed constraints. These tradeoffs are always recommended because failure to find a solution to these problems could stop the New System's acquisition.

- Recommend to higher authority ("RHA") tradeoff options that may have a significant impact but are decisions that must come from a higher authority.
- Drop ("D") tradeoffs that are not feasible based on a combination of acquisition phase, scope of authority, possible impact, and cost to perform the tradeoff.

- Record the recommendation (i.e., "RT," "RHA," or "D") on Worksheet 6.1-2.

Procedure 1 Example

This example continues the example in the preceding action step. The analyst prioritizes the tradeoff options.

Priority	Type	Number	Tradeoff Option Description
1	M	7	Use AVUM/AVIM AAPMH of 2,225/2,631 to compute Proposed System manpower.
2	T	12	Develop a training device for MOS 68F's electrical system training to reduce training on the actual aircraft.
3	W	5	Include integrated diagnostic equipment as part of the integrated cockpit design.
4	W	4	Replace the GFE equipment with contractor equipment. Contractor equipment that is equivalent to or exceeds New System requirements can be substituted. Data for the equipment must exist.
5	R&M	1	Use alternative TADS/PNVS BCS equipment available from Navy or other sources.
6	W	3	Redesign GFE (avionics and communications equipment) to reduce MOS 35K's maintenance responsibilities.
7	R&M	2	Replace the fully integrated Fire Control System with a segregated system.
8	P	10	Offer a first-term re-enlistment bonus to MOS 35K.
9	W	6	Strengthen helicopter tail frame and fuselage.
10	P	8	Offer a first-term re-enlistment bonus to MOS 68F.
11	P	9	Segment MOS 68F's training so that advanced electronics training is offered after firstterm re-enlistment or as a re-enlistment incentive.

(continued)

Procedure 1 Example (continued)

Priority	Type	Number	Tradeoff Option Description
12	T	13	Assign MOS 35K's proficiency training, included in course 102-35K10, to OJT in the unit.
13	P	11	Segment MOS 35K's training so that advanced avionics training is offered after first-term re-enlistment or as a re-enlistment incentive.

None of the 13 tradeoff options appears to have the potential to stop the New System's development/procurement.

Procedure 2 Example

The analyst determines each tradeoff option's feasibility based on the New System's acquisition phase, the TAG's authority, and the tradeoff's cost. Answers to the three questions asked in this procedure are displayed below.

Type	#	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost to Implement	Notes
M	7	Use AVUM/AVIM AAPMH of 2,225/2,631 to compute Proposed System manpower.		Y	L	(3)
T	12	Develop a training device for MOS 68F's electrical system training to reduce the training on the actual aircraft.			H	
W	5	Include integrated diagnostic equipment as part of the integrated cockpit design.	Y		H	(1)
W	4	Replace the GFE equipment with contractor equipment. Contractor equipment that is equivalent to or exceeds New System requirements can be substituted. Data for the equipment must exist.		Y	H	

(continued)

Procedure 2 Example (continued)

Type	#	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost to Implement	Notes
R&M	1	Use alternative TADS/PNVS BCS equipment available from the Navy or other sources.			M	
W	3	Redesign GFE (avionics and communications equipment) to reduce MOS 35K's maintenance responsibilities.			M	(2)
R&M	2	Replace the fully integrated Fire Control System with a segregated system.		Y	H	
P	10	Offer a first-term re-enlistment bonus to MOS 35K.		Y	H	(4)
W	6	Strengthen helicopter tail frame and fuselage.			L	(2)
P	8	Offer a first-term re-enlistment bonus to MOS 68F.		Y	H	(4)
P	9	Segment MOS 68F's training so that advanced electronics training is offered after first-term re-enlistment or as a re-enlistment incentive.			L	(5)
T	13	Assign MOS 35K's proficiency training, included in course 102-35K10, to OJT in the unit.		Y	L	(6)
P	11	Segment MOS 35K's training so that advanced avionics training is offered after first-term re-enlistment or as a re-enlistment incentive.			L	(5)

(continued)

Procedure 2 Example (continued)

Notes:

(1) The integrated cockpit is a major subsystem; redesigning it at the current stage of the acquisition would be difficult and costly.

(2) Similar to (1) above, however, the GFE or tail redesign could be implemented as a PIP or ECP, thereby avoiding acquisition delays.

(3) These are issues that deal with Army manpower policy; they are beyond the scope of the TAG's authority.

(4) Offering a first-term re-enlistment bonus can only be approved at the Department of the Army level.

(5) As long as unit skill sets and performance levels are not adversely affected, these tradeoffs may offer the TAG a low-cost training alternative that will improve the first-term retention of two key MOSs.

(6) The "yes" in the Scope of Authority column indicates that this option needs to be closely coordinated between materiel and combat developers.

Procedure 3 Example

The HCM team evaluates each tradeoff option and makes the following recommendations.

Type	#	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost to Implement	Recommendations
M	7	Use AVUM/AVIM AAPMH of 2,225/2,631 to compute Proposed System manpower.		Y	L	RHA
T	12	Develop a training device for MOS 68F's electrical system training to reduce training on the actual aircraft.			H	RT
W	5	Include integrated diagnostic equipment as part of the integrated cockpit design.	Y		H	D

(continued)

Procedure 3 Example (continued)

Type	#	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost to Implement	Recommendations
W	4	Replace the GFE equipment with contractor equipment. Contractor equipment that is equivalent to or exceeds New System requirements can be substituted. Data for the equipment must exist.		Y	H	D
R&M	1	Use alternative TADS/PNVS BCS equipment available from Navy or other sources.			M	D
W	3	Redesign GFE (avionics and communications equipment) to reduce MOS 35K's maintenance responsibilities.			M	RT
R&M	2	Replace the fully integrated Fire Control System with a segregated system.		Y	H	D
P	10	Offer a first-term re-enlistment bonus to MOS 35K.		Y	H	D
W	6	Strengthen helicopter tail frame and fuselage.			L	R
P	8	Offer a first-term re-enlistment bonus to MOS 68F.		Y	H	D
P	9	Segment MOS 68F's training so that advanced electronics training is offered after first-term re-enlistment or as a re-enlistment incentive.			L	RT
T	13	Assign MOS 35K's proficiency training, included in course 102-35K10, to OJT in the unit.		Y	L	D

(continued)

Procedure 3 Example (continued)

Type	#	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost to Implement	Recommendations
P	11	Segment MOS 35K's training so that advanced avionics training is offered after first-term re-enlistment or as a re-enlistment incentive.			L	R

Action Step 3: Select Tradeoffs and Identify Tradeoff Methods

Discussion

In this action step the HCM analysis team presents the prioritized list of tradeoff options to the TAG. The TAG then decides which tradeoffs will be performed.

In addition to assisting the TAG in selecting the tradeoff analyses to be performed, the HCM analysis team must help the TAG decide which type of tradeoff analysis will be performed. There are two types of tradeoffs: (1) rough order of magnitude (ROM) tradeoffs that test the sensitivity of MPT results to changes in certain key parameters, and (2) detailed tradeoff analyses that require that some or all of Steps 1, 2, 3, and 4 be iterated.

ROM tradeoffs are more suitable when the New System is in the early stages of the acquisition process (when the HCM MPT estimates are most uncertain) and when a wider range of feasible tradeoffs exists. Detailed MPT tradeoffs are used to refine ROM estimates or to determine the tradeoff option's exact effects.

When considering whether a ROM or detailed tradeoff analysis is appropriate, the analysis team must keep in mind that several ROM estimates can be performed for the same cost as one detailed estimate. The TAG is responsible for choosing the appropriate method. The TAG will base its decision on the number and range of tradeoff studies desired and the resources available to perform tradeoff analyses.

Procedures

1. **Select Tradeoffs.**
   - Discuss the tradeoff recommendations with the TAG.
   - As the TAG selects each tradeoff, circle that tradeoff on Worksheet 6.1-2.
2. **Identify Tradeoff Methods.**
   - Discuss the two types of tradeoffs with the TAG.
   - Working with the TAG, place either "ROM" or "D" in the Method column of Worksheet 6.1-2.

Procedure 1 and 2 Examples

The HCM analysis team records the tradeoff options and methods selected by the TAG. In this example the TAG has selected two ROM analyses and one detailed analysis.

Type	#	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost to Implement	Recommendation	Method
M	7	Use AVUM/AVIM AAPMH of 2,225/2,631 to compute Proposed System manpower.		Y	L	RHA	ROM
T	12	Develop a training device for MOS 68F's electrical system training to reduce training on the actual aircraft.			H	RT	Detailed
W	3	Redesign GFE (avionics and communications equipment) to reduce MOS 35K's maintenance responsibilities.			M	RT	ROM

SUBSTEP 6.1
WORKSHEETS

WORKSHEET 6.1-1

Use this worksheet to develop a tradeoff options list.

TRADEOFF TYPE	TRADEOFF NUMBER	TRADEOFF OPTION DESCRIPTION

WORKSHEET 6.1-2

Use this worksheet to select tradeoffs.

Priority	Tradeoff Type	Tradeoff Number	Tradeoff Option Description	Acquisition Phase	Scope of Authority	Cost of Analysis	Recommendation	Method		Notes
								ROM	Detailed	

Substep 6.2: Perform ROM Tradeoff Analysis

Overview

In this substep the HCM analysis team performs rough order of magnitude (ROM) tradeoff analyses. ROM tradeoffs permit the HCM analysis team to identify (1) the New System's MPT resource problems, (2) the severity of resource shortfalls, and (3) solutions for overcoming the shortfalls. ROM tradeoff analyses also identify potential secondary effects an improvement or change in one area may have on other MPT resource areas. Figure 6.2-1 is an overview of this substep.

In a ROM tradeoff analysis the HCM analysts construct graphs that show the relationship among certain MPT parameters. The graphs are either linear or step functions. The analysts construct one graph for each MOS or course affected by each tradeoff option.

After the analysts construct the graphs they determine ROM MPT estimates. The analysts determine the direct effect of the tradeoff option, recalculate the HCM parameter affected, and construct graphs using the updated values.

ROM tradeoff analyses and the resulting graphs provide a range of answers for Army decision makers. The answers bound a problem (i.e., "best possible case" and "worst possible case" answers). The Technical Advisory Team (TAG) can use ROM results to determine areas that require a detailed tradeoff analysis. A detailed tradeoff analysis should be conducted when the increased accuracy is worth the additional cost.

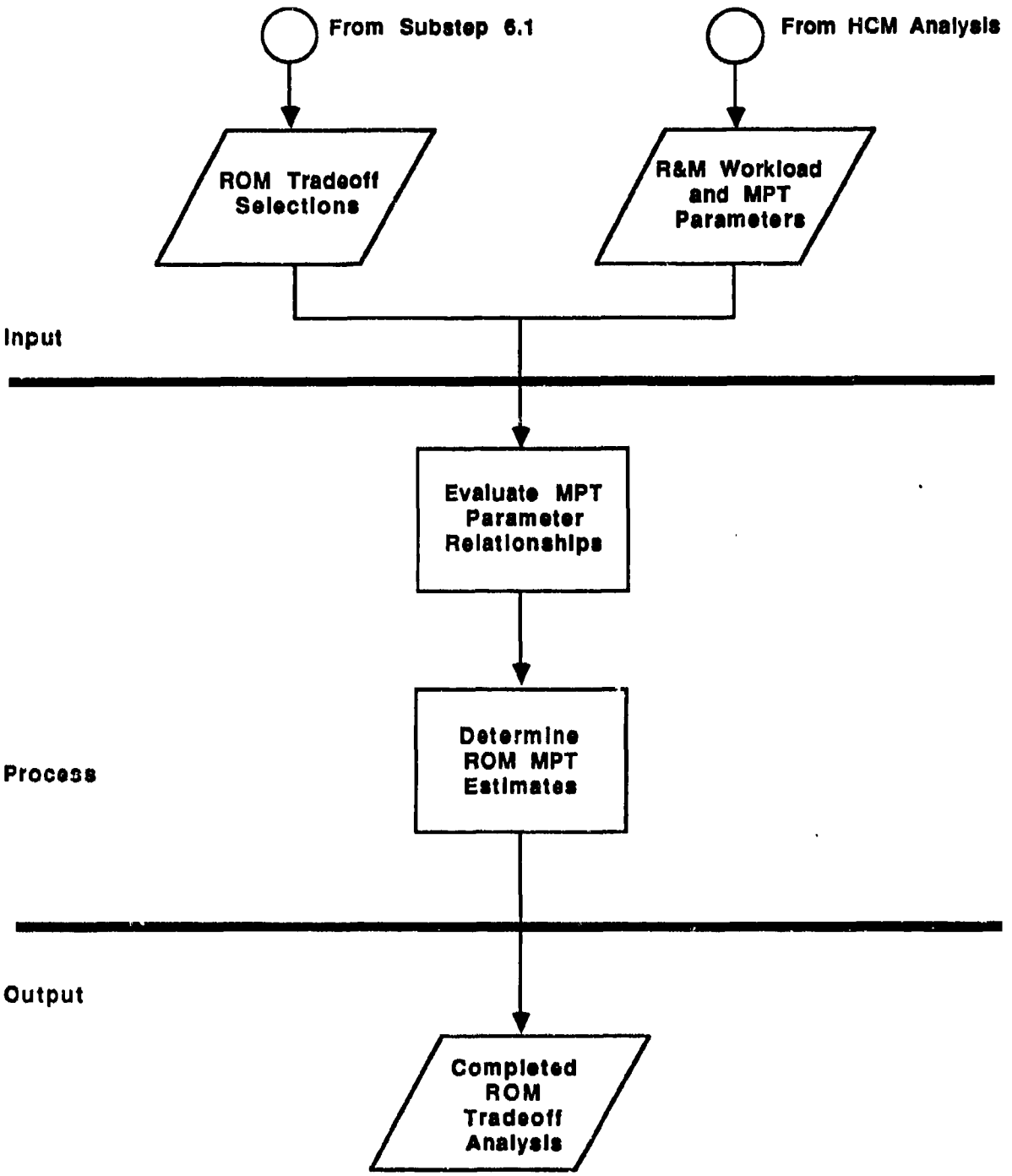

Figure 6.2-1. Overview of Substep 6.2, Perform ROM Tradeoff Analysis.

Action Step 1: Evaluate MPT Parameter Relationships

Discussion

In this action step the HCM analysts construct graphs of the relationships among workload, manpower, personnel, and training. The analysts can construct graphs of many different relationships. The following are five of the more common relationships:

(1) Workload and its effect on manpower

(2) Manpower and its effect on student input

(3) Student input and its effect on instructors

(4) Student input and its effect on training man-days

(5) Student input and its effect on course cost

The analysts must determine the relationships that must be graphed to study the tradeoff option. Usually, a workload tradeoff "ripples through" manpower, personnel, and training. A manpower tradeoff affects personnel and training, and a training tradeoff affects only training. The analyst would construct graphs 1 through 5 for a workload tradeoff; graphs 2 through 5 for a manpower tradeoff; and graphs 3 through 5 for a training tradeoff. If a workload tradeoff does not affect training, the analysts would not construct graphs 3 through 5.

Procedures

1. **Determine the MPT Parameter Relationships for Each ROM Tradeoff Option.**

   - Obtain the ROM tradeoff options from Substep 6.1 and record them on Worksheet 6.2-1. Consolidate the reliability and maintainability and workload tradeoff options into workload tradeoff options.
   - Use Table 6.2-1 to determine the MPT parameter relationships that apply to each tradeoff option. Record the parameter relationships on Worksheet 6.2-1.
   - Determine the number of MOSs and courses that will be affected by each tradeoff option and record them on Worksheet 6.2-1.

Table 6.2-1. Relationship of the Five MPT Parameters.

Parameter Relationships	ROM Approximations	Graphs to be Constructed	Tradeoff Types			
			Workload	Manpower	Personnel	Training
(1) Workload-to-Manpower	Step Function (whole) or Linear (fractional)	For Each MOS at the Lowest Organizational Units	X			
(2) Manpower-to-Student Input	Linear	For Each Course Affected	X	X	X	
(3) Student Input-to-Instructors	Step Function	For Each Course Affected	X	X	X	X
(4) Student Input-to-Training Man-Days	Linear	For Each Course Affected	X	X	X	X
(5) Student Input-to-Course Costs	Linear	For Each Course Affected	X	X	X	X

- Determine the number of graphs required to represent each parameter relationship and each MOS and course. Record the number of graphs on Worksheet 6.2-1.
- Determine whether each graph will be a linear or step function.
- Construct the appropriate graphs for each tradeoff option.

  Workload-to-Manpower Graph

  - Plot manpower on the Y-axis (the vertical axis). Draw separate graphs for each paygrade, maintenance level, and unit. Use several X-axis (horizontal) scales, one for the workload assigned to each paygrade.
  - Size the total manpower graph to accommodate the potential improvement resulting from the tradeoff option.
  - Use the following equation to define the workload-to-manpower graph:

$$TM = \sum_{i=1}^{k} N_i \cdot \frac{\text{Workload}_i}{\text{APMH}_i}$$

Where:

TM	=	Total Manpower
Workload_i	=	Workload for Each Organizational Unit of Type i
APMH_i	=	The APMH Value for Organizational Unit i
N_i	=	Number of Organizational Units of Type i in the Force Structure
K	=	Number of Types of Organizational Units

  - Apply the following rounding rule if manpower for the organizational unit "i" is computed as whole positions.

(1) Round down if the decimal remainder of the total manpower derived is less than 0.5.

(2) Round up if the decimal remainder of the total manpower derived is greater than or equal to 0.5.

(3) After rounding, multiply by N*i* in the above equation.

- Clearly mark the HCM values of workload and manpower for each paygrade and document the values on Worksheet 6.2-1.

Manpower-to-Student Input Graph

- Using Worksheet 6.2-1, identify the MOSs affected by the tradeoff.
- Plot student input on the Y-axis.
- Enter the student input and the manpower requirement on Worksheet 6.2-1.
- Size each graph to accommodate the anticipated improvement of the tradeoff option.
- For each course, plot the line represented by the following equation:

$$y = \frac{\text{Present Student Input}}{\text{Present Manpower Requirement}} \quad x$$

This is equivalent to drawing a straight line between the HCM analysis results for each paygrade and point (0,0) on the graph.

Student Input-to-Instructors Graph

- Using Worksheet 6.2-1, list the courses affected by the tradeoff.
- Record both the student input and the instructors for each course. Plot the instructors on the Y-axis and the student input on the X-axis.
- Size each graph to accommodate the anticipated improvement of the tradeoff option.
- Plot the student input-to-instructors relationship as a step function. Compute the step width and step increment. Determine the values of student input at which the number of instructors increases by one or more and the value at which it decreases by one or more. Compute the step width as follows:

Step width = TI(+) - TI(−)

Where:

TI(+) = Student Input Value at which the Number of Instructors Increases

TI(−) = Student Input Value at which the Number of Instructors Decreases

- Construct the graphs using equal-sized steps for a range of student input/instructors.

Student Input-to-Training Man-Days Graph

- Using Worksheet 6.2-1, list the student input, the training man-days, and courses affected by the tradeoff.
- Plot the student input on the X-axis.
- Size each graph to accommodate the anticipated improvement of the tradeoff option.
- For each course, plot the line represented by the following equation:

$$y = \frac{\text{Present Training Man-Days}}{\text{Present Student Input}}$$

This is equivalent to drawing a straight line between the HCM analysis results for each course and point (0,0) on the graph.

Student Input-to-Course Cost Graph

- Using Worksheet 6.2-1, list the courses affected by the tradeoff.
- Record the student input on the X-axis and the course costs on the Y-axis.
- Size each graph to accommodate the anticipated improvement of the tradeoff option.
- For each course, plot the line represented by the following equation:

$$y = \frac{\text{Present Course Cost}}{\text{Present Student Input}} \; x$$

This is equivalent to drawing a straight line between the HCM analysis results for each course and point (0,0) on the graph.

Procedure 1 Example

The analyst records the ROM tradeoffs on Worksheet 6.2-1. In this example, none of the tradeoffs is a consolidated tradeoff.

Type	Tradeoff Number	ROM Tradeoff Option Description
M	7	Use AVUM/AVIM AAPMHs of 2,225/2,631 to compute Proposed System manpower
W	3	Redesign GFE (avionics and communications equipment) to reduce MOS 35K's maintenance responsibilities

A detailed example is provided here for a single workload tradeoff option (W-3). Using tradeoff option W-3, the analyst constructs graphs of the five parameter relationships in Table 6.2-1. The tradeoff affects MOS 35K and courses 102-35K10 (35K entry level) and 4C-F18/102-ASIW6 (to train 35K MOS for the Additional Skill Identifier [ASI] W6). The analyst constructs the parameter relationship graphs as discussed below.

Workload-to-Manpower Graph

MOS 35K manpower occurs only at the AVUM level. The analyst will not address individual skill levels in this example. Therefore, the workload-to-manpower graph will consist of a single plot of total manpower to total workload for MOS 35K. For simplicity, only Attack Battalion III (ATKH BN III) is shown.

The analyst constructs the graph by first determining the manpower equation:

$$\text{Total Manpower} = N \quad \frac{(\text{Workload})}{\text{APMH}}$$

Where N, workload, and APMH, refer to the values at the ATKH BN III (AVUM):

N = 3
APMH = 1,241
Workload (35K) = 13,312.8 MMH

The analyst notes that the workload-to-manpower plot will be a step function because the manpower total is displayed as whole rather than fractional positions.

Procedure 1 Example (continued)

The manpower for ATKH BN III is 11 35Ks. The analyst aggregates the workload and manpower (in this case multiplying by 3) and marks this point on the graph.

Figure 6.2-2 is the graph for a single Attack Battalion. Figure 6.2-3 shows 35K workload for one system across the entire Active Army.

In reviewing the graph in Figure 6.2-2 the analyst notes the following:

1. The total manpower/workload for MOS 35K is clearly marked.
2. Because of the way manpower is aggregated, the manpower steps are increments of three manpower positions.
3. The manpower value is located on the left half of the step equal to 32-34; this indicates that a relatively small savings in workload may provide a savings of three manpower positions (30-32).

The graph in Figure 6.2-3 shows total Active Army manpower to total workload for MOS 35K and will be used for examples in Action Step 2. The graph is a complex step function resulting from summing terms for each contributing organizational unit in the manpower equation. Each term is described below.

Active force total manpower:

i	Organizational Unit	N_i	$APMH_i$	35K Manpower
1	ATKH BN III	3	1,241	Whole Position
2	ATKH BN V	3	1,241	Whole Position
3	ATKH BN VII	3	1,241	Whole Position
4	ATKH BN XVIII	3	1,241	Whole Position
5	ATKH BN HVY II	6	1,241	Whole Position
6	ATKH BN HVY IA	2	1,241	Whole Position
7	ATKH BN EAC NEA	2	1,241	Whole Position
8	ATKH BN HVY DIV IB	4	1,241	Whole Position

Manpower-to-Student Input Graph

The analyst draws two manpower-to-student input graphs for MOS 35K, one each for courses 102-35K10 and 4C-F18/102-ASIW6. Although both courses are for Skill Level 1, the latter course is an ASI course attended by some but not all members of the MOS.

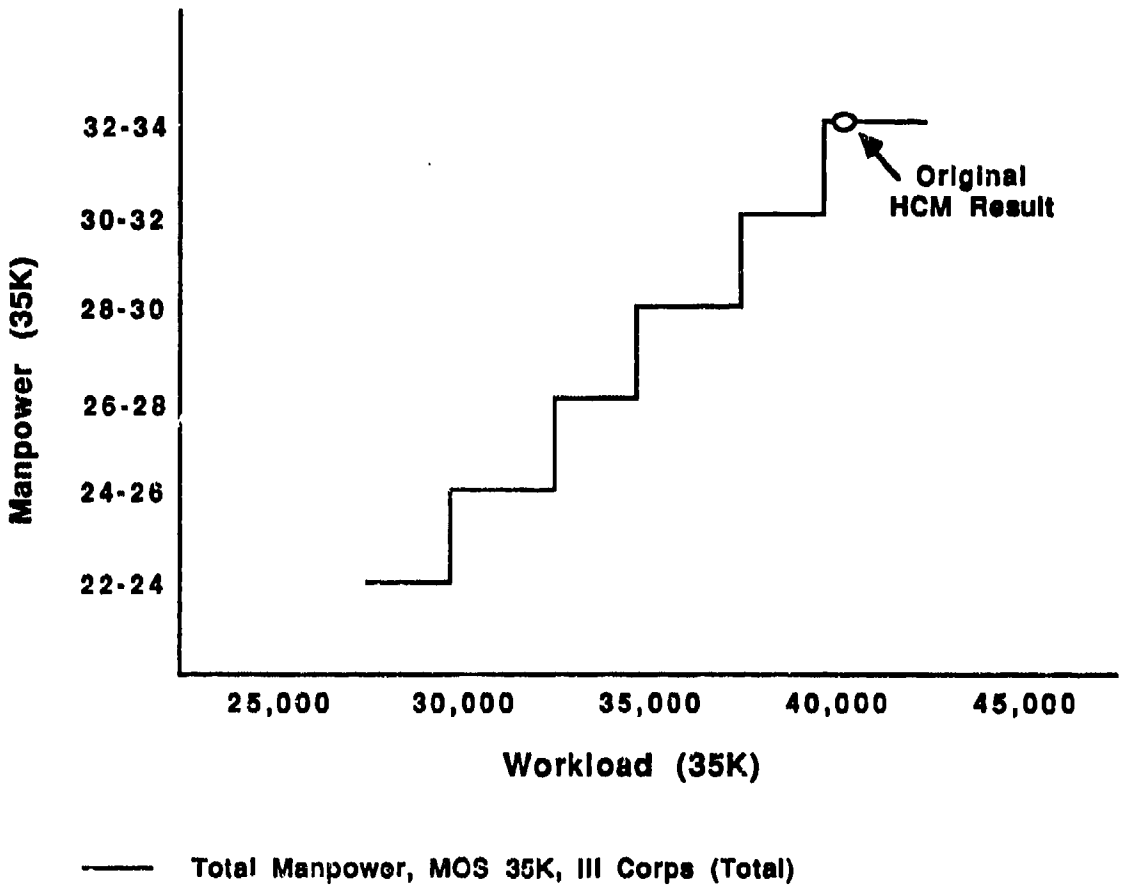

Figure 6.2-2. Workload-to-Manpower Graph for an Individual Unit.

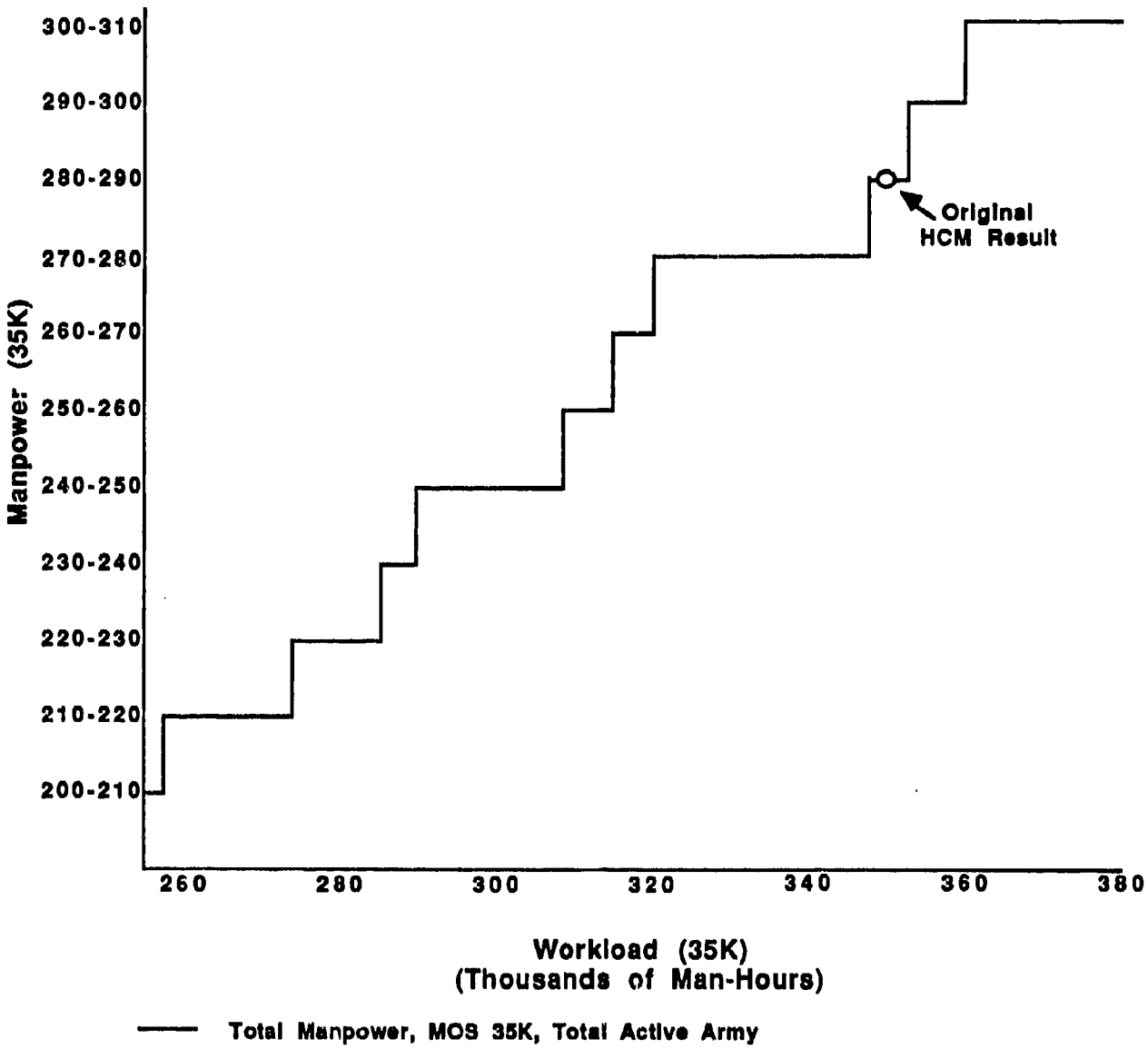

Figure 6.2-3. Workload-to-Manpower Graph for Total MOS 35K Workload.

Procedure 1 Example (continued)

The analyst constructs the manpower-to-student input graphs by first determining the student input to each MOS 35K course.

	Paygrade			
	E-3	E-4	E-5	Total
Manpower	143	57	86	286
Student Input				
102-35K10	82	0		82
4C-F18/102-ASIW6	0	24		24

Although MOS 35K manpower is computed in whole rather than fractional positions, the manpower-to-student input graph is displayed as a continuous, linear function. The manpower and student input are marked on each graph.

Figure 6.2-4 shows the graph for course 102-35K10. Figure 6.2-5 shows the graph for course 102-ASIW6. The graph for course 102-35K10 (Figure 6.2-4) shows that a 10-percent reduction in manpower from 143 to 129 provides a student input of 74.

Student Input-to-Instructors Graph

The analyst draws one graph of the student input-to-instructors relationship for each 35K course. This relationship is a more complex function than the workload-to-manpower step function. The number of instructors depends primarily on the mix of media selected for a course (other factors may include the number of training locations, etc.). If any element of the tradeoff option involves changes in media. The analyst must place separate plots for alternative media mixes on a single graph of the course.

The analyst constructs the student input-to-instructors graph by determining the following:

Course	Instructors	Total Student Input
102-35K10	8	82
4C-F18/102-ASIW6	1	24

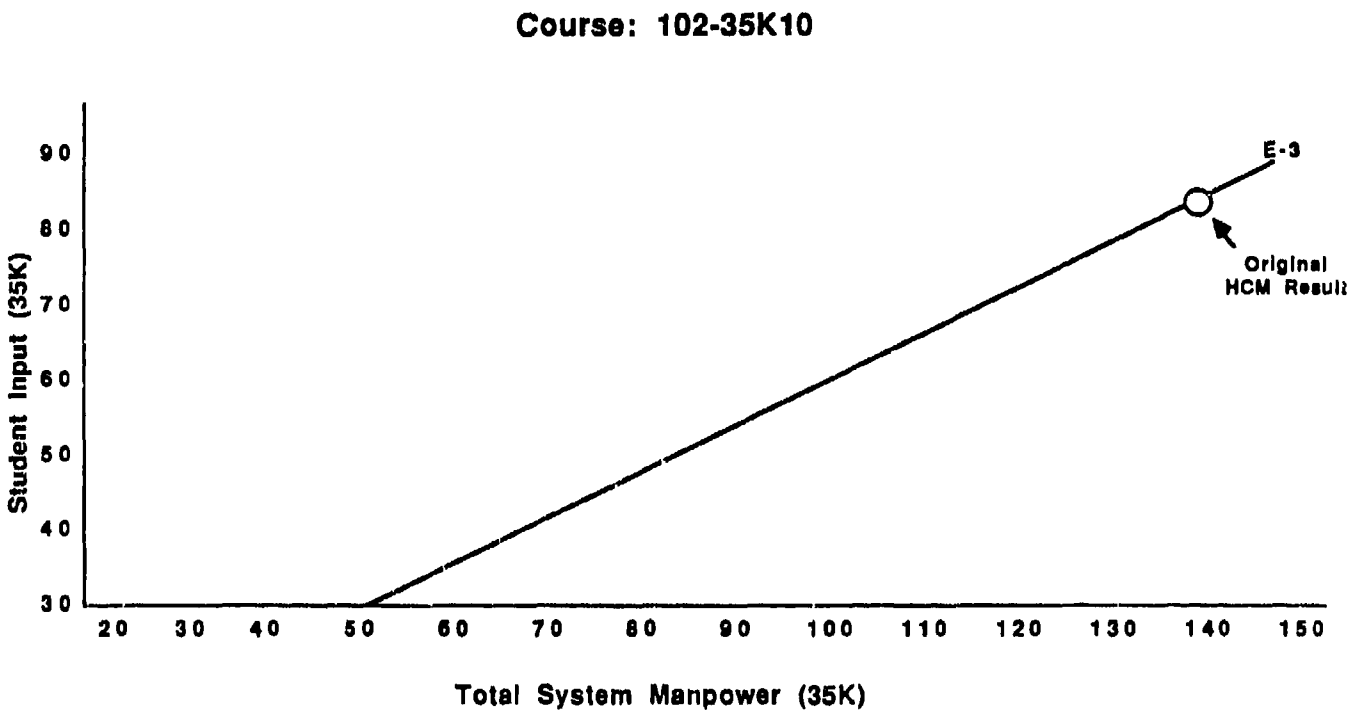

Figure 6.2-4. Manpower-to-Student Input Graph for Course Number 102-35K10.

Course: 4C-F18/102-ASIW6

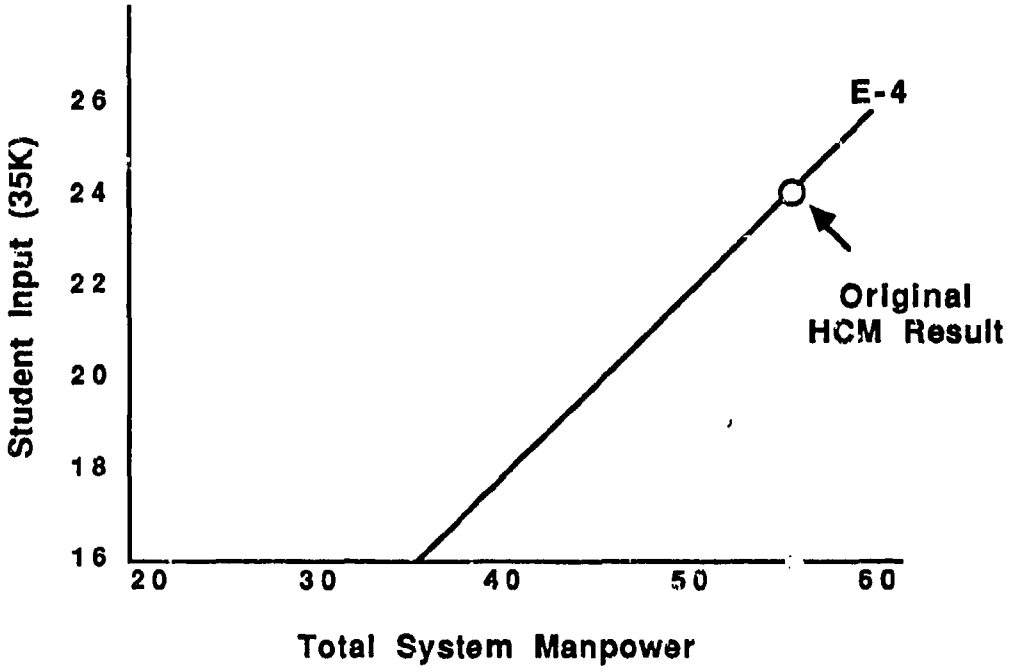

Figure 6.2-5. Manpower-to-Student Input Graph for Course Number 4C-F18/102-ASIW6.

Procedure 1 Example (continued)

The analyst determines the student input at which the number of instructors would increase to 9 and the student input at which instructors would decrease to 7. The analyst also determines the student input for the 4C-F18/102-ASIW6 course at which the number of instructors would increase to 2 and the student input at which the fractional number of instructors equals 0.5. The graphs were constructed using equal-sized steps for a range of student input and instructor values.

Figure 6.2-6 shows an alternative media mix and the associated group sizes. This media mix would save 2 instructors (8 versus 6 instructors) for a student input of 82.

The graph in Figure 6.2-7 shows that all "steps" are of equal width except the step corresponding to one instructor. The student input must be zero for the number of instructors to be zero.

Student Input-to-Training Man-Days Graph

The analyst constructs one graph for each course to show the student input-to-training man-days relationship. The training man-days depend primarily on the course content and media selection for a course. If any element of the tradeoff option involves changes in course length, the analyst must place separate plots for the alternative course lengths on a single graph.

The analyst constructs the student input-to-training man-days graphs by determining the total training man-days for each MOS 35K course.

Course	Total Training Man-Days	Total Student Input
102-35K10	10,630	132
4C-F18/102-ASIW6	707	24

The analyst then plots the training man-days and student input for each course on each graph.

The graph for course 102-35K10 (Figure 6.2-8) shows an alternative course. This alternative course could reduce the number of training man-days by approximately 1,280 (10,630 versus 9,350). Figure 6.2-9 shows the graph for 4C-F18/102-ASIWG.

Student Input-to-Course Cost Graph

The analyst constructs one graph for each MOS 35K course to show the student input-to-course cost relationship. Course cost depends primarily on course length and training equipment. If any element of the tradeoff option involves changes in course length or training equipment, then the analyst must place separate plots for the alternate courses on a single graph.

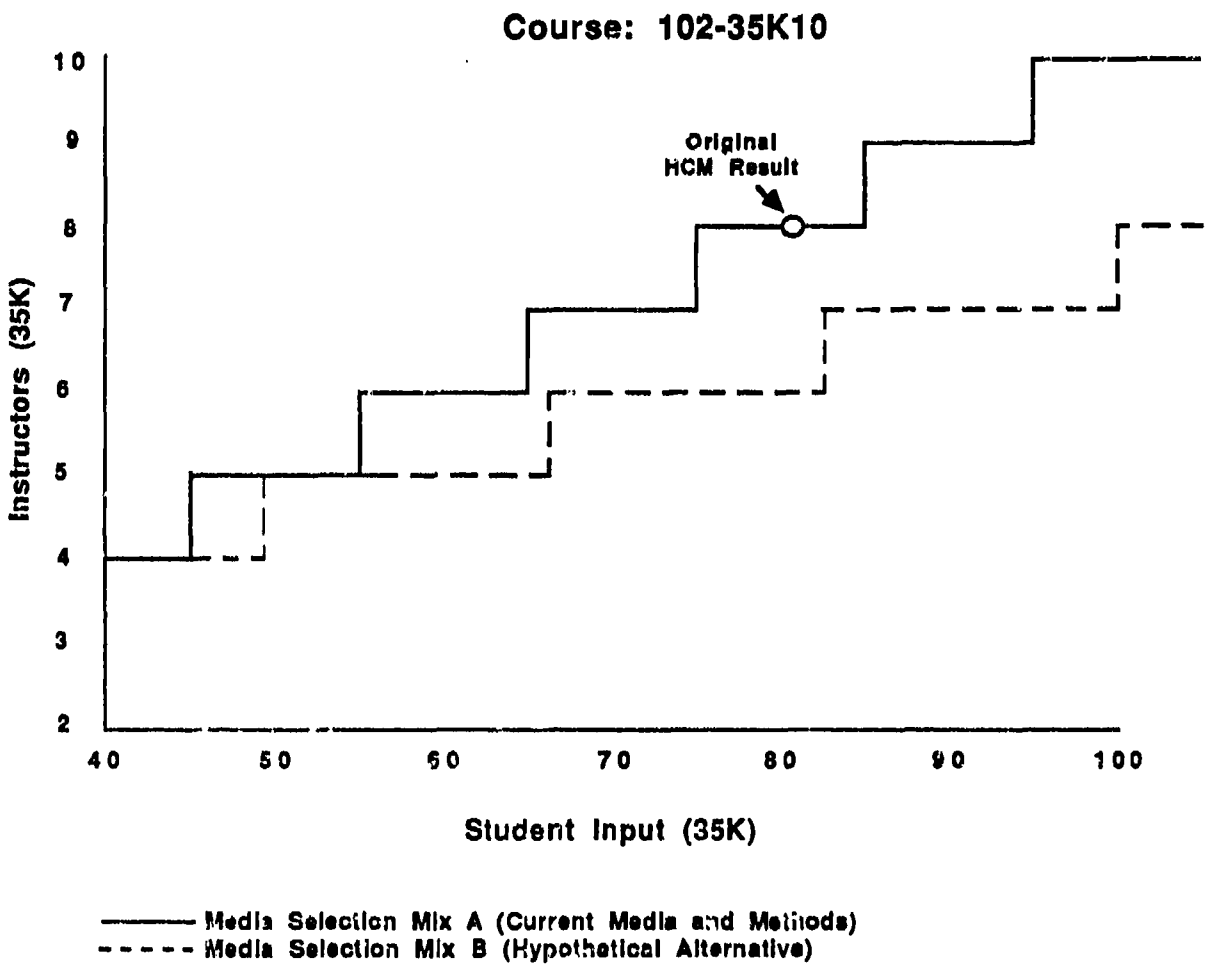

Figure 6.2-6. Student Input-to-Instructors Graph for Course Number 102-35K10.

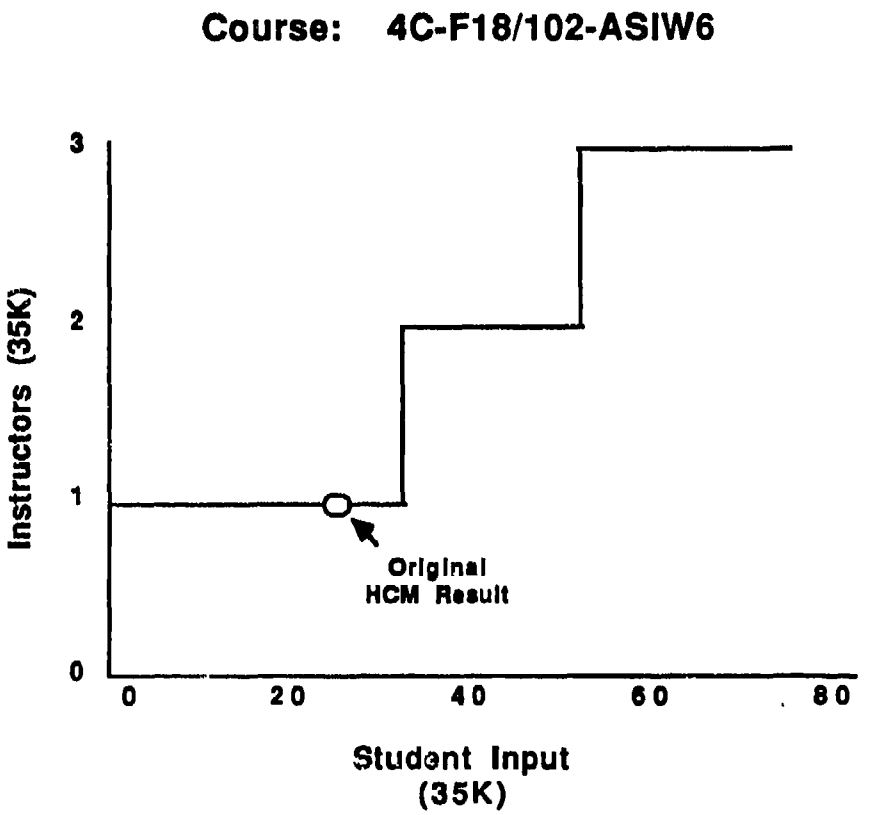

Figure 6.2-7. Student Input-to-Instructors Graph for Course Number 4C-F18/102-ASIW6.

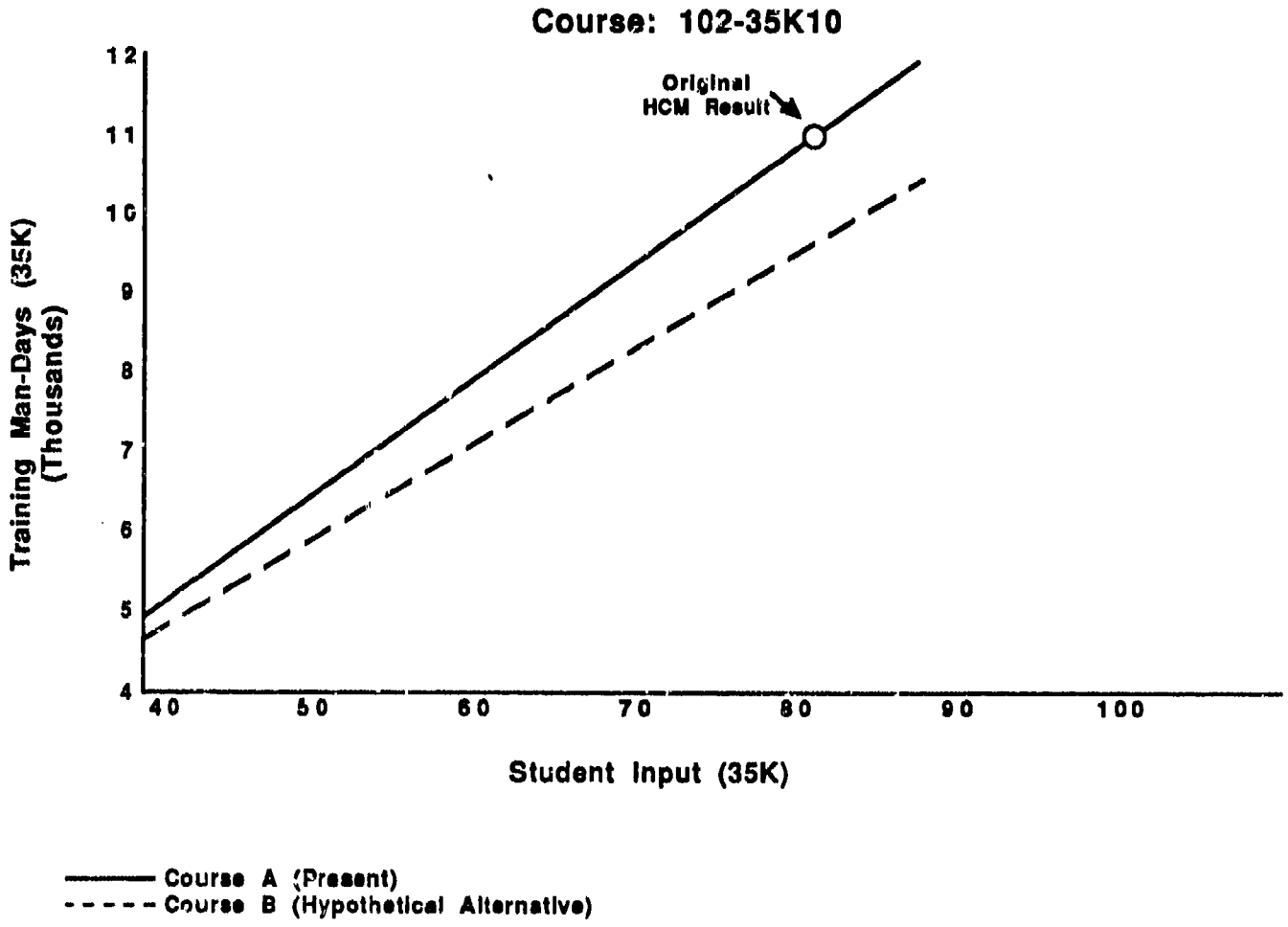

Figure 6.2-8. Student Input-to-Training Man-Days Graph for Course Number 102-35K10.

Course: 4C-F18/102-ASIW6

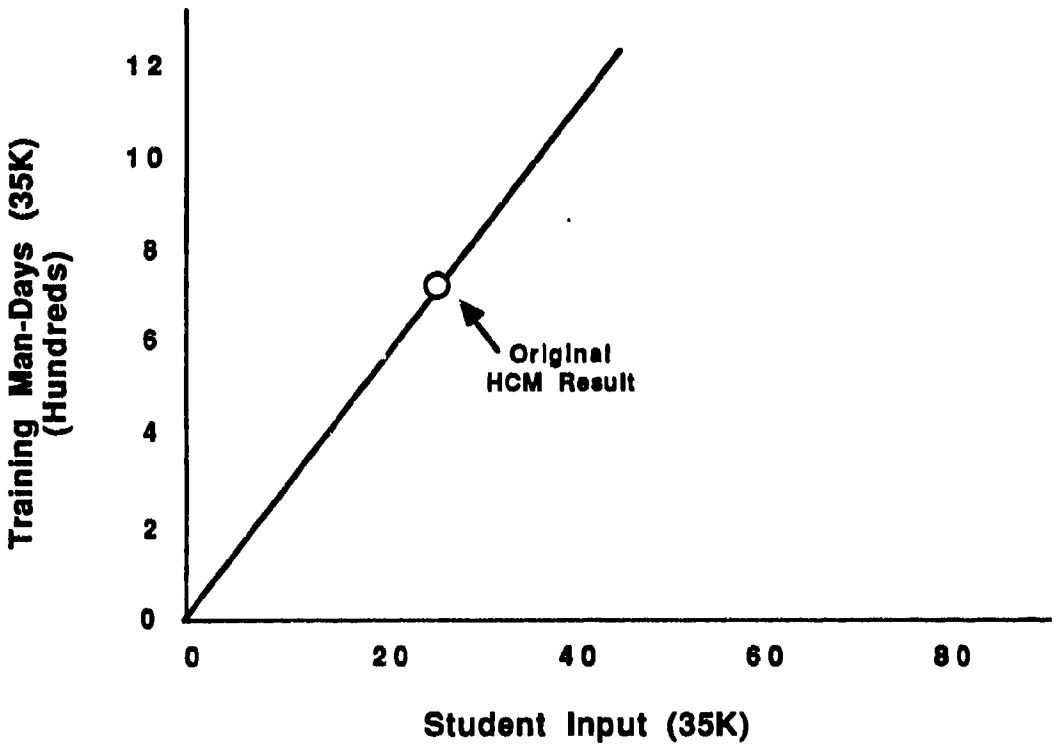

Figure 6.2-9. Student Input-to-Training Man-Days Graph for Course Number 4C-F18/102-ASIW6.

Procedure 1 Example (continued)

The analyst constructs the student input-to-course cost graphs by first determining the total course costs for each MOS 35K course.

Course	Total Course Cost ($K)	Total Student Input
102-35K10	906	82
4C-F18/102-ASIW6	161	24

The analyst plots the student input-to-course cost values for each course on each graph.

Figure 6.2-10 shows the graph for course 4C-F18/102-ASIW6.

The graph for course 102-35K10 (Figure 6.2-11) shows an alternative course. This alternative course may reduce training costs by approximately 129K (906K versus 777K) for the student input of 82.

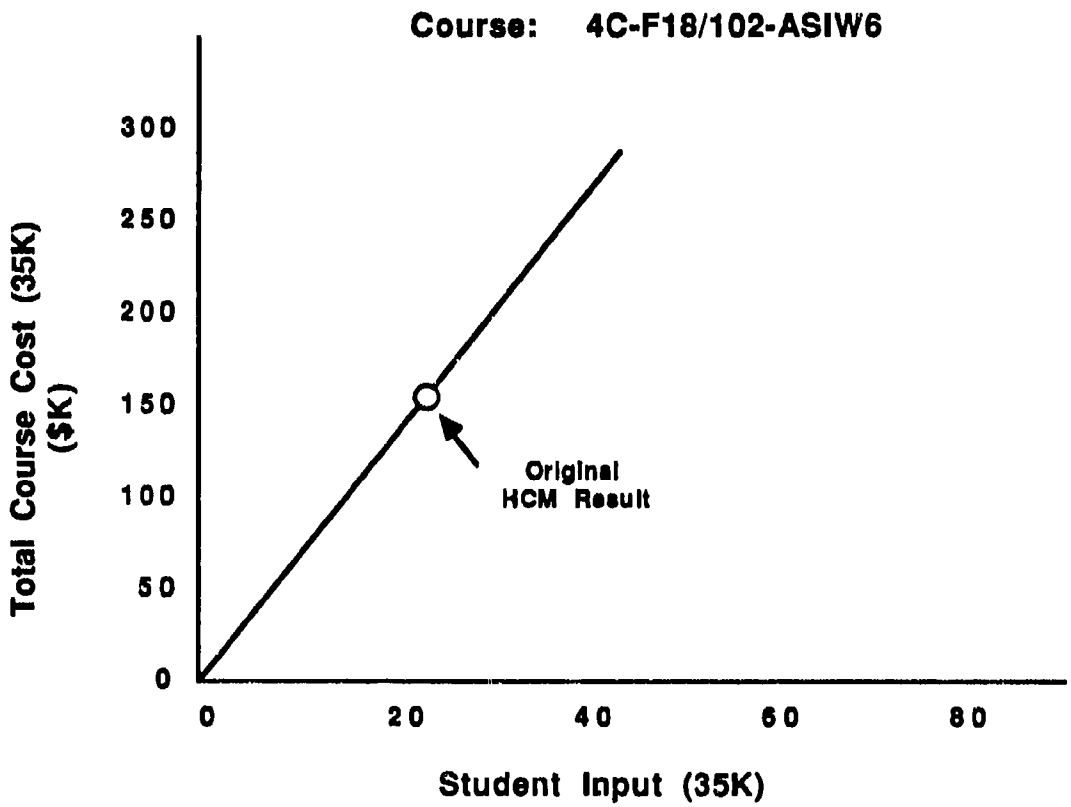

Figure 6.2-10. Student Input-to-Course Cost Graph for Course Number 4C-F18/102-ASIW6.

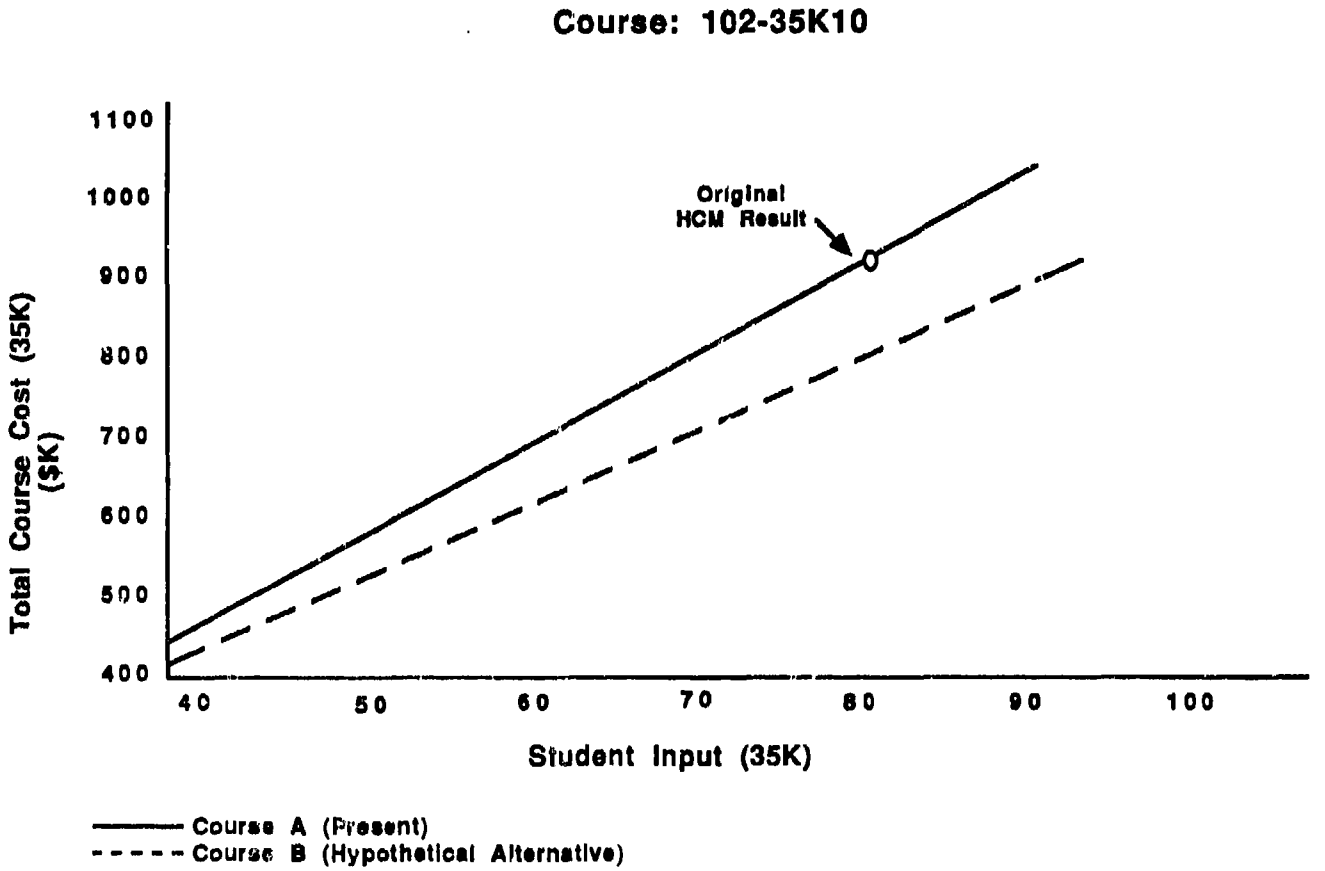

Figure 6.2-11. Student Input-to-Course Cost Graph for Course Number 102-35K10.

Action Step 2: Determine ROM MPT Estimates

Discussion

In this action step the analyst first determines the direct effect of each tradeoff option on the appropriate HCM parameter. He or she then recalculates the HCM parameter. For example, a manpower tradeoff option to increase the Annual Available Productive Man-Hours (AAPMH) would require the recalculation of only manpower requirements using the new AAPMH. The analyst uses the new parameter result and the ROM graphs to determine the tradeoff option's secondary or "ripple" effects on the remaining MPT parameters.

Some tradeoff options may require the analyst to construct new graphs (i.e., new linear or step functions) that reflect a change in parameter relationships. For example, a tradeoff option that changes the training course requirements (e.g., longer/shorter course), will alter the relationship of student-input-to-training costs. This change is reflected in the slope of the new graph.

Procedures

1. **Evaluate the Direct Effect of Each ROM Tradeoff Option.**
   - Determine the relevant HCM procedures required to implement the tradeoff option. Limit the procedures to those directly affected by the tradeoff option.
   - Use these procedures to recalculate or otherwise determine the direct effect of the tradeoff option on the appropriate HCM parameter.
   - Record the new parameter values on Worksheet 6.2-2 in the Tradeoff Result column.
2. **Evaluate Other Effects of the Tradeoff Option.**
   - Use the parameter relationship graphs to evaluate the secondary effects of each tradeoff option.
   - Workload-to-Manpower. For each MOS affected by the tradeoff:
     - Use the MOS workload from the Tradeoff Result column of Worksheet 6.2-1 as the X-axis input to the workload-to-manpower graph.

- Determine the total MOS manpower of the Y-axis where the X-axis value intersects the plot.
- Determine the paygrade breakdown of the manpower result either:
  (1) directly, if separate paygrade plots are displayed on the workload-to-manpower graph;
  (2) by using Army Standards of Grade Authorization; or
  (3) by proportionally adjusting the present paygrade breakdown.
- Record the total manpower and the paygrade breakdown on the Tradeoff Result column of Worksheet 6.2-1.

• Manpower-to-Student Input. For each course affected by the tradeoff:
- Use the MOS manpower by paygrade from the Tradeoff Result column of Worksheet 6.2-1 as the X-axis input to the manpower-to-student input graph.
- Determine the MOS student input by paygrade from the Y-axis where the X-axis value intersects the appropriate plot.
- Determine the total MOS student input by summing the student input for each paygrade.
- Record the total and by paygrade student input in the Tradeoff Result column of Worksheet 6.2-1.

• Student Input-to-Instructors. For each course affected by the tradeoff:
- Use the total student input for the MOS from the Tradeoff Result column of Worksheet 6.2-1 as the X-axis input to the student input-to-instructors graph.
- Determine the number of instructors from the Y-axis where the X-axis value intersects the appropriate plot.
- Record the number of instructors in the Tradeoff Result column of Worksheet 6.2-1.

• Student Input-to-Training Man-Days. For each course affected by the tradeoff:

- Use the total student input for the MOS from the Tradeoff Result column of Worksheet 6.2-1 as the X-axis input to the student input-to-training man-days graph.
- Determine the training man-days from the Y-axis where the X-axis value intersects the appropriate plot.
- Record the training man-days in the Tradeoff Result column of Worksheet 6.2-1.

• Student Input-to-Course Cost. For each course affected by the tradeoff:

- Use the total student input for the MOS from the Tradeoff Result column of Worksheet 6.2-1 as the X-axis input to the student input-to-course cost graph.
- Determine the course cost from the Y-axis where the X-axis value intersects the appropriate plot.
- Record the course cost in the Tradeoff Result column of Worksheet 6.2-1.

Procedure 1 Example

The analyst determines that the tradeoff option will generate a 14.2-percent reduction in total system workload (a reduction from 353,000 to 303,000 MMH/year). The analyst records the justification of this tradeoff as shown below:

Parameter	Original HCM Result	Tradeoff Result	Justification Notes
Total MOS 35K Workload (MMH/year)	353,000	303,000	(1)

(1) MOS 35K Preventive and Corrective Maintenance requirements for Government Furnished Equipment (GFE) can be reduced by approximately 50,000 MMH/year by updating GFE circuitry and installing a common interface with test equipment.

Procedure 2 Example

The ROM analysis of tradeoff "W-3" will progress through five parameter relationship graphs.

Workload-to-Manpower Analysis

The analyst uses the total MOS 35K workload (303,000 MMH/year) as the X-axis input to the total active Army workload-to-manpower graph (Figure 6.2-3). This generates a total manpower value of 242 for MOS 35K.

The paygrade breakdown of the manpower total will be proportionally computed as follows:

	Original HCM Manpower Result	Tradeoff Result	
E-3	143	(120.99)	121
E-4	57	(48.23)	48
E-5	86	(72.77)	73
Total	286		242

Procedure 2 Example (continued)

Manpower-to-Student Input Analysis

The analyst uses the MOS 35K manpower by paygrade from the Tradeoff Result column above. The values (121 for E-3, 48 for E-4) serve as the X-axis input to the two manpower-to-student input graphs for MOS 35K. One graph for each MOS 35K course was constructed in the preceding action step. The student input results are as follows:

Course	Original HCM Result Student Input	Tradeoff Result
102-35K10	82	69
4C-F18/102-ASIW6	24	20

Student Input-to-Instructors Analysis

The analyst uses the total student input for each MOS 35K course from the Tradeoff Result column above. The values (69 for course 102-35K10 and 20 for course 4C-F18/102-ASIW6) serve as the X-axis input to the corresponding student input-to-instructors graph constructed in the preceding action step. The instructor results are as follows:

Course	Original HCM Result Instructors	Tradeoff Result
102-35K10	8	6
4C-F18/102-ASIW6	1	1

A hypothetical alternative course plot was drawn in the example graph constructed for course 102-35K10 in the previous action step. The unbroken line plot represents the student input-to-instructor relationship for the new course using the current course media. The tradeoff result value is represented by the dotted line plot. The dotted line plot would have been drawn when performing Procedure 1 of this action step.

Student Input-to-Training Man-Days Analysis

The analyst uses the total student input for each MOS 35K course. The values (69 for course 102-35K10 and 20 for course 4C-F18/102-ASIW6) serve as the X-axis input to the corresponding student input-to-training man-day graph constructed in the preceding action step. The training man-day results are:

Course	Original HCM Result Man-Days	Tradeoff Result
102-35K10	10,630	9,350
4C-F18/102-ASIW6	707	590

Procedure 2 Example (continued)

A hypothetical alternative course plot was drawn on the graph constructed for course 102-35K10. The dotted line plot represents the student input-to-training man-day relationship for the alternative course.

Student Input-to-Course Cost Analysis

The analyst uses the total student input for each MOS 35K course. The values (69 for course 102-35K10 and 20 for course 4C-F18/102-ASIW6) serve as the X-axis input to the corresponding student input-to-course cost graph constructed in the preceding action step. The course cost results are as follows:

Course	Original HCM Result Training Cost ($K)	Tradeoff Result ($K)
102-35K10	906	1,040
4C-F18/102-ASIW6	161	130

The analyst refers to the graph constructed for course 102-35K10. The analyst notes that an alternative course plot was drawn. The dotted line plot represents the student input-to-course cost relationship for the alternate course.

Figure 6.2-12 is an example of a completed ROM analysis.

WORKSHEET 6.2-1

Use this worksheet to document ROM tradeoff analyses.

Tradeoff Type	Tradeoff Number	Tradeoff Option Description	Parameter Relationships	Number of MOSs	Number of Courses	Number/ Type of Graphs
W	3	Redesign GFE (avionics and communications equipment) to reduce MOS 35K's maintenance responsibilities.	Workload-to-Manpower	1		1 Step
			Manpower-to-Student Input		2	2 Linear
			Student Input-to-Instructors		2	2 Step
			Student Input-to-Training Man-Days		2	2 Linear
			Student Input-to-Course Cost		2	2 Linear

Figure 6.2-12. Example of a ROM tradeoff analysis.

WORKSHEET 6.2-2

Use this worksheet to document the ROM tradeoff analyses.

AFFECTED WORKLOAD/ MPT PARAMETERS	ORIGINAL HCM RESULTS	TRADEOFF RESULT	AUDIT TRAIL
MOS 35K - Total Workload (MMH/year)	353,000	303,000	(1)
MOS 35K - Manpower			
E-3	143	121	
E-4	57	48	
E-5	86	73	
Total	286	242	
MOS 35K - Student Input			
Course 102-35K10			
Total	82	69	
Course 4C-F18/102-ASIW6			
E-4/Total	24	20	
MOS 35K - Total Training Resources			
Course 102-35K10			
Instructors	8	6	
Training Man-Days, Annual	10,630	9,350	
Total Course Cost ($K), Annual	906	1,040	
Course 4C-F18/102-ASIW6			
Instructors	1	1	
Training Man-Days, Annual	707	590	
Total Course Cost ($K), Annual	161	130	

Figure 6.2-12. Example of a ROM tradeoff analysis (continued).

SUBSTEP 6.2
WORKSHEETS

WORKSHEET 6.2-1

Use this worksheet to document ROM tradeoff analyses.

Tradeoff Type	Tradeoff Number	Tradeoff Option Description	Parameter Relationships	Number of MOSs	Number of Courses	Number/ Type of Graphs

WORKSHEET 6.2-2

Use this worksheet to document ROM tradeoff analyses.

AFFECTED WORKLOAD/ MPT PARAMETERS	ORIGINAL HCM RESULTS	TRADEOFF RESULT	AUDIT TRAIL

Substep 6.3: Perform Detailed Tradeoff Analysis

Overview

In this substep the HCM analysts perform a detailed tradeoff analysis. In Substep 6.1 the HCM team presented the TAG with a prioritized list of tradeoff options. The TAG selected the tradeoffs to be performed and chose the tradeoff method, either a rough order of magnitude (ROM) or detailed analysis. Substep 6.2 described the ROM tradeoff analysis method. This substep provides procedures for iterating the HCM to analyze the effect that changes to the New System's design and concepts will have on the system's MPT requirements. Figure 6.3-1 is an overview of this substep.

Some or all of HCM Steps 1 through 4 are iterated in detailed tradeoff analyses; hence these analyses are not performed as often as ROM analyses. The exact number and nature (ROM versus detailed) of tradeoffs depends largely on the resources available.

Although this substep requires the iteration of HCM Steps 1 through 4, examples of procedures already described in this guide are not repeated.

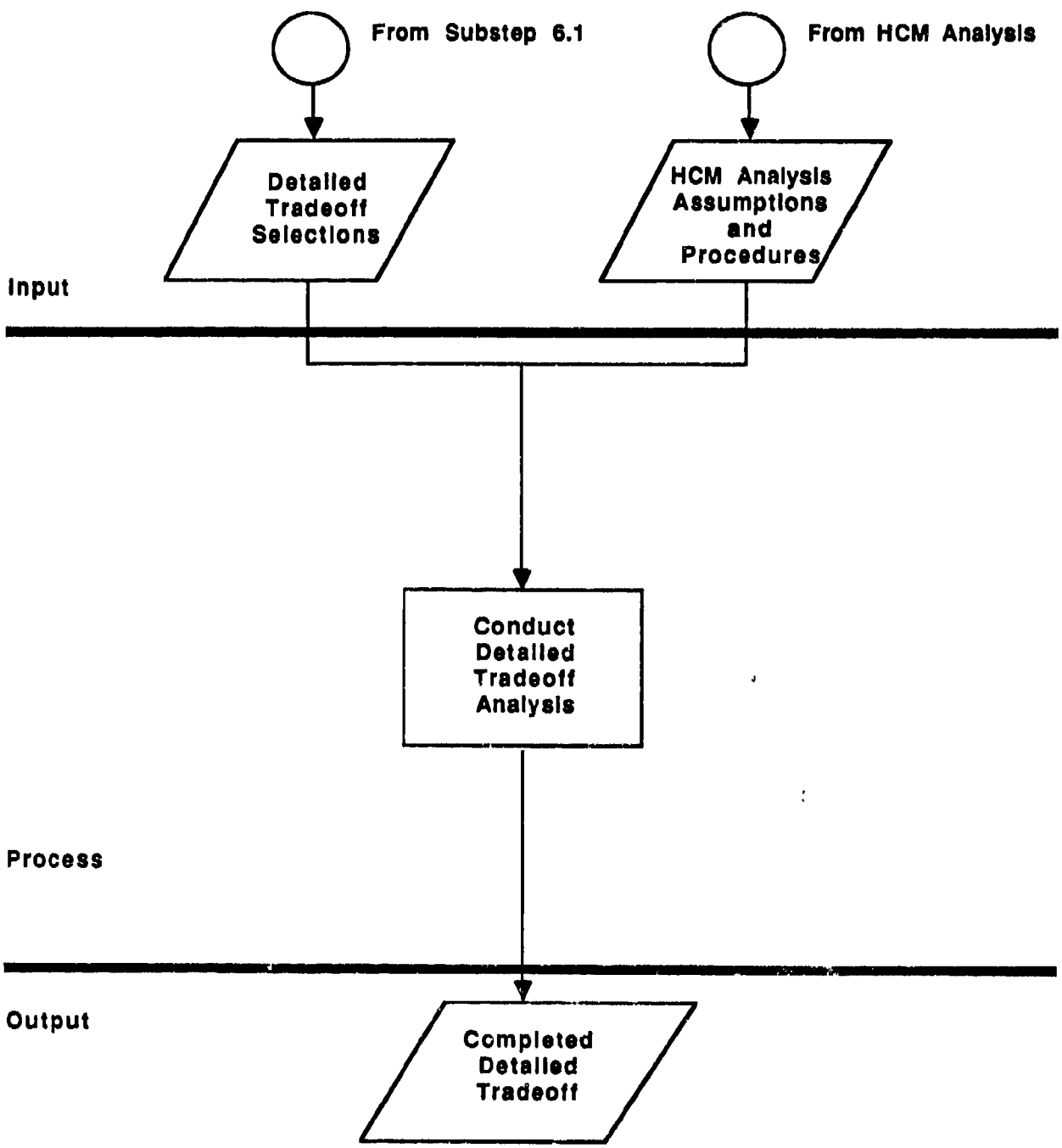

Figure 6.3-1. Overview of Substep 6.3, Perform Detailed Tradeoff Analysis.

Action Step 1: Conduct Detailed Tradeoff Analysis

Discussion

In a detailed tradeoff analysis the HCM analysts repeat some or all of HCM Steps 1 through 4. The analysts repeat these steps to determine the impact of each tradeoff option. The analysts must carefully select the HCM steps and substeps that they will iterate as part of the detailed tradeoff analysis.

NOTE

Tradeoffs relating to maintenance requirements (type "R&M") are directly related to the development of workload. Workload, in turn, is the basis for all subsequent manpower, personnel, and training products. "R&M" tradeoff options, therefore, are grouped with type "W" tradeoff options in this substep.

Procedures

1. **Determine Tradeoff Scope.**
   - Transfer from Worksheet 6.1-2 to Worksheet 6.3-1 the "Type," "Number," and "Tradeoff Option Description."
   - List on Worksheet 6.3-1 the HCM analysis steps and substeps that must be performed to reassess all facets of the tradeoff.
   - Indicate in the Notes column of Worksheet 6.3-1 the assumptions and/or data that must be modified.
   - List in the Additional Data column of Worksheet 6.3-1 any additional data necessary to iterate the indicated steps.
   - Collect all additional data needed to analyze the tradeoff before proceeding to Action Step 2.
2. **Conduct HCM Tradeoff Iteration.**
   - Perform the HCM steps and substeps listed on Worksheet 6.3-1 to evaluate the impact of the tradeoff option. Refer to Steps 1 through 4 for the specific procedures for each step.
   - On Worksheet 6.3-2 array the results of each detailed tradeoff and the original HCM results.
   - Prepare tradeoff results and conclusions for TAG review, if necessary.
   - Document tradeoff conclusions in the HCM audit trail and final reports, as necessary.

Procedure 1 Example

One detailed tradeoff was identified in Substep 6.1. This example is a continuation of the training tradeoff option T-12 example in Substep 6.1.

Type	Number	Tradeoff Option Description
T	12	Develop a training device for MOS 68F's electrical system training to reduce training on the actual aircraft

The training analyst then determines the substeps that must be performed to analyze the impact of tradeoff option T-12. Usually, only HCM Step 4 will be performed for a training tradeoff. The following substeps will not be performed, for the reasons indicated:

Substep	Reason
4.2	Analysis scope does not include training task analysis
4.4	Analysis scope does not include course material requirements
4.9	Analysis scope does not include unit training material requirements

The training analyst then determines the analysis assumptions and data that must be modified to accomplish the tradeoff option.

The training analyst identifies additional data that must be collected prior to performing the detailed tradeoff analysis. The analyst must collect training information for a training device comparable to the proposed training device.

Procedure 2 Example

The training analyst repeats Substeps 4.1, 4.3, 4.5, 4.6, 4.7, and 4.8 using revised assumptions and additional data. The training analyst compares the tradeoff results with the original HCM results, as shown in Figure 6.3-2. The analyst then presents the results and conclusions to the TAG and documents them in the HCM final reports.

WORKSHEET 6.3-1

Use this worksheet to document the detailed tradeoff analyses.

Tradeoff Type	Tradeoff Number	Tradeoff Option Description	HCM Steps/ Substeps	Additional Data	Notes
T	1 2	Develop a training device for MOS 68F's electrical system training to reduce the training on actual aircraft	Step 4	Comparable training device information	
			Substeps 4.1		Modified training concept substitutes a training device for actual aircraft in MOS 68F training
			4.3	Training effectiveness comparison between actual aircraft training devices	
			4.5	Student/instructor ratio for comparable training device	Physical space constraint eased for purposes of determining student/ instructor ratios
			4.6		
			4.7		
			4.8	Cost factors to include: training device development costs, training device operation and support costs, "value" of relinquishing actual aircraft time from the school house training mission, etc.	

Figure 6.3-2. Example of a detailed tradeoff analysis.

WORKSHEET 6.3-2

Use this worksheet to document detailed tradeoff analyses.

WORKLOAD/MPT PARAMETERS	ORIGINAL HCM RESULTS	TRADEOFF RESULT
MOS 68F - Total Training Resource		
Course 602-68F10		
Instructors	74	70
Training Man-Days, Annual	85,108	83,640
Total Course Cost ($K), Annual	7,520	4,735*
		* Includes a savings of 12 aircraft-weeks per year devoted to the training mission
Course 602-68F30		
Instructors	2	2
Training Man-Days, Annual	2,783	2,743
Total Course Cost ($K), Annual	328	243*
		* Includes a savings of 1 aircraft-week per year devoted to the training mission

Figure 6.3-2. Example of a completed detailed tradeoff analysis (continued).

SUBSTEP 6.3

WORKSHEETS

WORKSHEET 6.3-1

Use this worksheet to document the detailed tradeoff analyses.

Tradeoff Type	Tradeoff Number	Tradeoff Option Description	HCM Steps/ Substeps	Additional Data	Notes

WORKSHEET 6.3-2

Use this worksheet to document detailed tradeoff analyses.

WORKLOAD/HPT PARAMETERS	ORIGINAL HCM RESULTS	TRADEOFF RESULT

APPENDIX A: ACRONYMS AND ABBREVIATIONS

AAPMH	Annual Available Productive Man-Hours
APMH	Available Productive Man-Hours
ASI	Additional Skill Identifier
AVIM	Aviation Intermediate Maintenance
AVUM	Aviation Unit Maintenance
BCS	Baseline Comparison System
BIT/BITE	Built-In Test/Built-In Test Equipment
ECP	Engineering Change Proposal
EIC	Equipment Identification Code
FA	Field Artillery
GFE	Government Furnished Equipment
HCM	Hardware versus Manpower (HARDMAN) Comparability Methodology
ICH	Instructor Contact Hours
IPR	In-Process Review
MANPRINT	Manpower and Personnel Integration
MCAF	Maintainability-Centered Adjustment Factor
MMBMA	Mean [Metric] Between Maintenance Actions
MMH	Maintenance Man-Hours
MOS	Military Occupational Specialty
MPT	Manpower, Personnel, and Training
MR	Maintenance Ratio
MTTR	Mean Time to Repair
OJT	On-the-Job Training
O&O	Organizational and Operational
PIP	Product Improvement Program
RCAF	Reliability-Centered Adjustment Factor
R&M	Reliability and Maintainability
ROM	Rough Order of Magnitude
SME	Subject-Matter Expert
TAADS	The Army Authorization Document System
TAG	Technical Advisory Group
TRADOC	Training and Doctrine Command

APPENDIX B: GLOSSARY

Audit Trail A systematic mechanism for tracking development of MPT requirements and monitoring changes to the data, assumptions, or procedures that produce the MPT requirements.

Baseline Comparison System (BCS) A current operational system, or a composite of current operational subsystems that most closely represents the design, operational, and support characteristics of the New System (MIL-STD-1388-1A).

Comparability Analysis The process by which estimates of an emerging weapon system's human-resource requirements are derived from the known requirements of similar operational systems and subsystems.

Detailed Tradeoff Analysis A type of tradeoff analysis that involves repeating some or all of the HCM using different assumptions and data.

Hardware versus Manpower (HARDMAN) Comparability Methodology A six-step process for determining a weapon system's manpower, personnel, and training requirements.

High Driver A system element that consumes a large proportion of MPT resources.

Impact Analysis Analysis of the effect of the New System's projected MPT requirements on available MPT resources.

In-Process Review A meeting between the HCM analysis team and the Technical Advisory Group. The purpose of the meeting is to review results and resolve problems.

Manpower The total demand, expressed in terms of the number of individuals, associated with a system (MIL-STD-1388-1A). That is, the number of individuals in each MOS, ASI, skill level, and paygrade required to operate and maintain a system.

New System (1) The system that is replacing the Predecessor System, and (2) the system being studied in a HARDMAN Comparability Methodology (HCM) analysis.

Predecessor System An existing system that is performing a mission or missions that will eventually be performed by the New System.

Proposed System An analytical construct used to determine the functional requirements of a New System. It incorporates technological advances likely to exist before the system's projected initial operational capability date.

Rough Order of Magnitude A type of tradeoff analysis that estimates a weapon system's MPT resource problems, the severity of resource shortfalls, and methods by which the shortfalls can be overcome.

Technical Advisory Group The Army group with interest in the HCM analysis.

Tradeoff Analysis An analysis conducted among a number of system alternatives. In an MPT front-end analysis, the goal is to determine the alternative that has the least impact on MPT, while still providing performance and availability rates required by the system to accomplish its missions.

Tradeoff Option A system design or concept alternative that could reduce the effect of MPT high drivers.